THE GLASS INDUSTRY

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HARTFORD DEVELOPS NEW SYSTEM OF GLASS MELTING

Two measuring feeders delivering through a triangular doghouse automatically distribute islands of batch through the tank according to a predetermined pattern. Factories equipped with this system are said to have demonstrated many economies and improved quality of finished ware.

A new glass melting system, characterized as one of the most outstanding developments in this field since the advent of automatic glass making processes, has been announced by the Hartford Empire Company. The system provides an accurately controlled method of applying an entirely new principle of automatic furnace charging; namely, that the greatest melting efficiency is obtained when the batch is placed in the furnace in measured amounts and in a distribution planned with respect to the individual firing method, time of reversal, and tonnage pull of the particular tank furnace.

The effectiveness of this new principle is stated to have been tested over an extended period of commercial operation, and is said to have resulted in improved glass quality as well as increased furnace yield. Hartford engineers, interviewed by a representative of THE GLASS INDUSTRY, stated that the batch feeders themselves had been in use and under test in the experimental plant of the Company for about seven years, both on a continuous tank and on numerous day tanks. Recently, several of the complete batch feeding systems have been installed in glass plants in the eastern part of the country, and other installations are now in process. The results, they stated, have been uniformly satisfactory in every instance.

A member of the staff of THE GLASS INDUSTRY was privileged to view one of these recent installations. Most striking was the complete absence of any furnace sting-out, or visible evidence of the furnace heat. All that could be seen from the rear of the furnace was a simple, compact machine that seemed to be an integral part of the furnace structure.

Through a special fritting arch construction of the doghouse, the full heat of the furnace is applied to the surface of the batch within the dogouse. This insures that the surface of the batch will have been well glazed over before the batch issues into the furnace proper where there could be impingment by the flame. It is apparent therefore that this minimizes the pick-up of batch dust which ordinarily is a serious source of trouble with crown, ports and particularly checkers.

Any exposition of this important new development of the Hartford-Empire Company should emphasize at the outset that it is not merely a new mechanical device for batch feeding, but a complete melting system. This system comprises in the main a specially constructed triangular-shaped doghouse and fritting arch, at the rear center of the furnace; a pair of novel batch feeding machines, which it is important to note are also devices for accurately measuring the batch input; the standard Hartford glass level gauge; and control instruments for automatically producing the desired cycle of operation.

As stated in the opening paragraph, the outstanding feature of the new batch feeding system is that it places

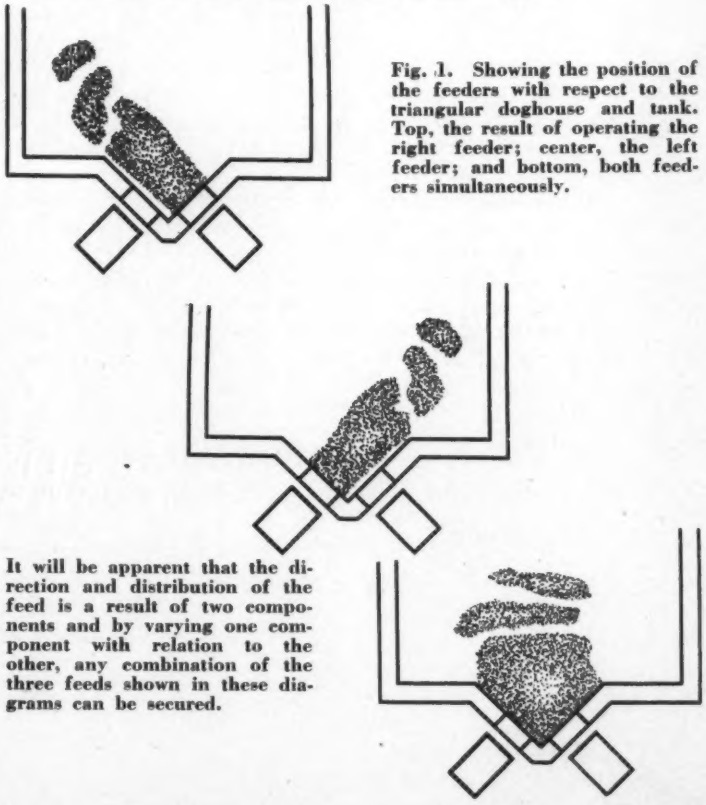


Fig. 1. Showing the position of the feeders with respect to the triangular doghouse and tank. Top, the result of operating the right feeder; center, the left feeder; and bottom, both feeders simultaneously.

It will be apparent that the direction and distribution of the feed is a result of two components and by varying one component with relation to the other, any combination of the three feeds shown in these diagrams can be secured.

the batch in the tank according to a planned distribution. This distribution takes the form of a series of separated masses or islands. The pattern of these islands is carefully varied with respect to the characteristics and requirements of the individual tank, and no two tanks will necessarily have the same pattern worked out for them.

Two important factors are involved in the creation of these batch patterns; the triangulation of the doghouse and the cycle of operation of the feeders. Reference to Fig. 1 is suggested in connection with the following discussion. As shown in this diagram, there are two batch feeders, one on each face of the doghouse. Each batch feeder directs a stream of batch diagonally toward one side of the furnace. When both feeders are operating simultaneously, the two streams of batch will meet and merge into a single stream, whose movement is along the center line of the tank. It will be apparent that by combining the two components of motion and the time of operation of the two feeders, the pattern of batch in the tank can be varied as desired.

Thus the batch may be placed symmetrically with relation to the center line of the furnace, or it can be placed more to one side than the other so as to form a non-symmetrical pattern. It is frequently desirable to feed a larger portion of the batch toward the side of the furnace away from the burners which are firing. By giving proper consideration to the convection currents in the molten glass, any desired pattern may be obtained which, of course, gradually disappears as the islands of batch melt in moving toward the fining end. It should be noted that a reversal of the tank necessitates, in the case of a non-symmetrical batch pattern, a reversal of the pattern itself, in order to maintain its proper position in the tank with relation to the direction of the fire.

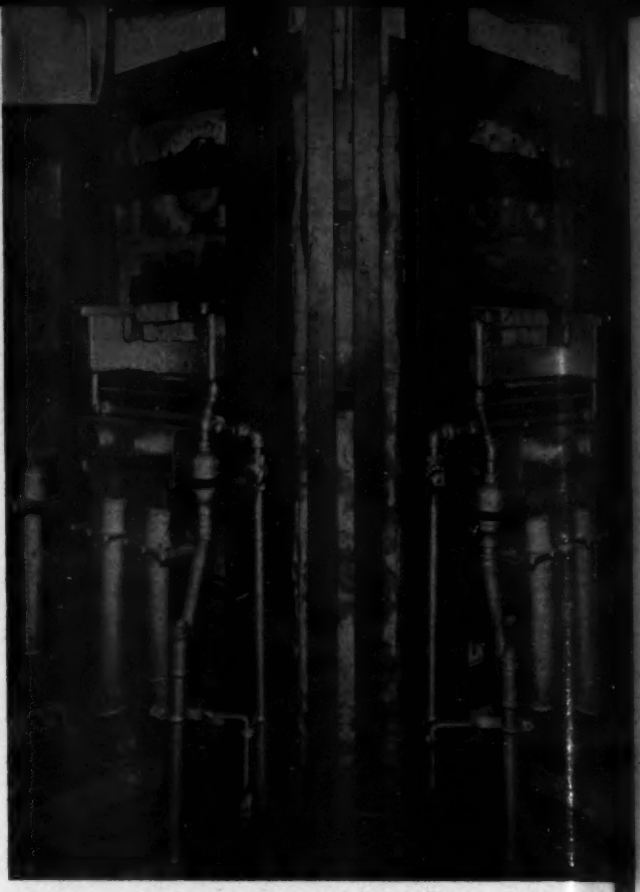
Operation of any intermittent batch feeding system requires by definition a series of delay intervals followed by the action of the feeder itself. In the new Hartford system, this "stop and go" cycle is controlled by timing instruments on a control panel.

A given cycle of operations is set in motion by the reversal of the furnace; or, on a non-regenerative tank, by a time interval control. When a furnace reversal is made, contact is broken with one limit switch, and made with another and by this means timers on the control panel, are set in motion and the batch feeding operation becomes automatic.

All of this is greatly simplified for the tank foreman, who simply has to set a series of six timing dials according to a chart provided him. One such chart, calculated for a particular tank now in actual operation, is illustrated here. By setting these timing dials according to the pull desired, which the operator reads from the chart, he initiates a sequence of operations and idle periods of the feeders. Reference to the panel shows it to be divided into three sections: the center section controls the dwell and time of operation of both feeders simultaneously, while the two outer sections control the dwell before operation and the time of operation of the respective feeders, as marked.

Always bearing in mind that the cycle of operation may be varied widely to suit changes in production schedule and different furnace conditions, two typical examples will be described.

On a small tank having a pull of 24 tons of glass per 24 hours, the center panel was thrown out of operation



Center line view of the triangular doghouse ready to have the batch feeders moved into place, showing the piping for air cooling the feeder mechanism and the metal line of the doghouse blocks. The water cooled sill may be seen just below the feeder opening, the latter having been temporarily sealed with brick.

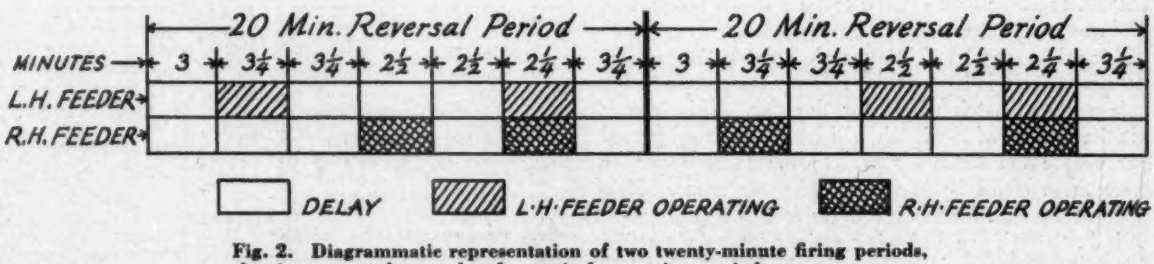


Fig. 2. Diagrammatic representation of two twenty-minute firing periods, showing a complete cycle of a typical operating period.

because it was not desired to have both feeders operating simultaneously. The right and left feeders were operated for equal time periods in the same cyclic order. The feeders operated at about 30 reciprocations per minute and a 1⅛" stroke was used. The furnace was operated on a 15 minute reversal period. Immediately following the reversal, both feeders were idle for 2¼ minutes; then the right feeder operated for 3 minutes, followed by a 4½ minute idle period; next the left feeder operated for 3 minutes, followed by an idle period of 2¼ minutes, at the end of which time the tank was reversed and the same cycle repeated.

Another typical installation was arranged to feed 70 tons per 24 hours, larger sized feeders were used and the stroke was set at 2¼". The reversal period was 20 minutes. When the tank was reversed, the following cycle (Fig. 2) was initiated: Both feeders were idle for 3 minutes; then the left feeder operated for 3¼ minutes. After an idle or delay period of 3¼ minutes the right feeder operated for 2½ minutes. Both feeders then remained idle for 2½ minutes, after which they both started in operation for 2¼ minutes. After both feeders stopped operating, there was a dwell of 3¼ minutes, at the end of which time the furnace was reversed and the next cycle started.

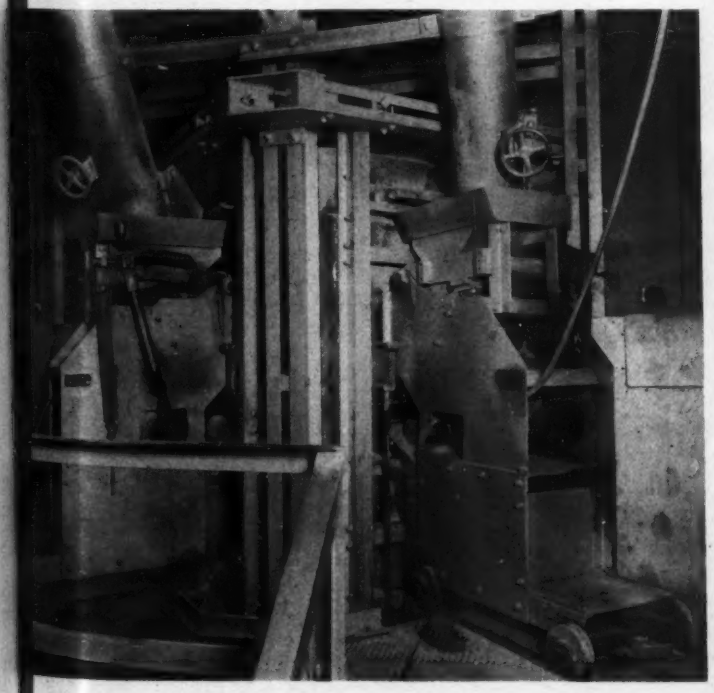
In order to maintain the same relation between the burners which were firing, and the pattern of the batch, the control-board automatically changed the connections so that if the right feeder fed in the first cycle, the left feeder fed in the second and vice versa. Thus the next cycle occurred in the same time sequence, but the operating feeder was changed from right to left and left to right. Therefore, the next cycle started out with a 3 minute idle period, followed by a 3¼ minute operation of the right feeder instead of the left. The cycle then continued with the opposite feeder operating in each instance.

A word as to the feeders themselves; for while the new Hartford batch feeding system is essentially a system, in which all elements contribute to the final result, yet the actual feeding mechanism is definitely novel and embodies interesting features.

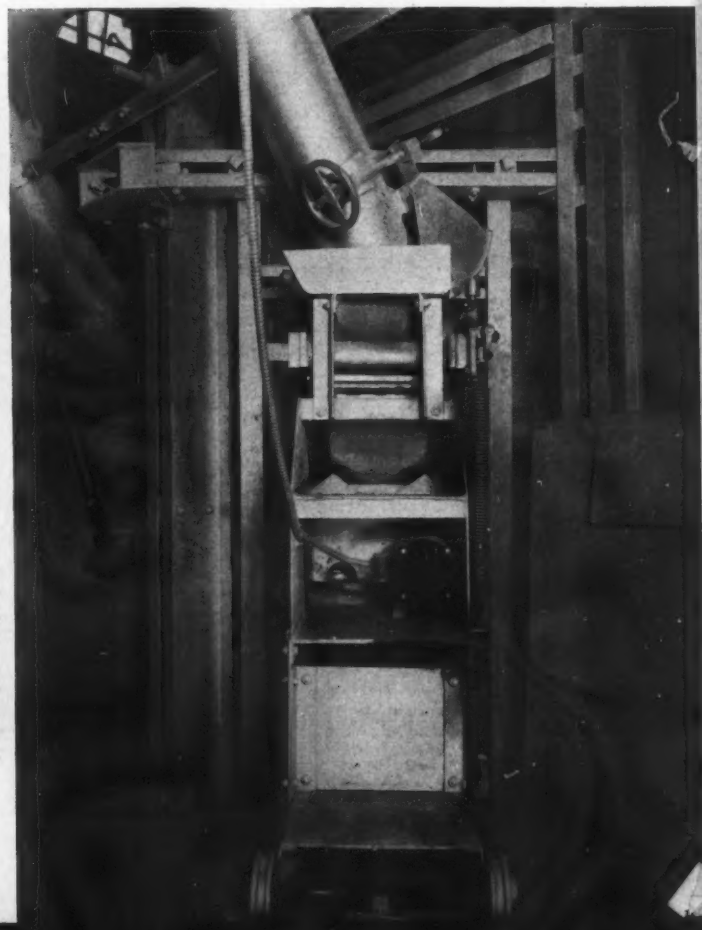
The new Hartford batch feeders are simple and rugged in construction, the main frame being of welded steel. This latter is supported on wheels and tracks, the wheels being equipped with roller bearings. A complete feeder weighs from 3,000 to 5,400 pounds. As may be seen from the illustrations, they fit tightly against the furnace structure, with an adjustable seal. Contacting parts are at all times insulated from the fire by the batch itself. Feeders are made in three sizes, 18", 24" and 30". These sizes refer to the width of the doghouse openings, and while speaking of insulation it should be stated that the doghouse openings are protected by water cooled sills and covers.

The quantity of batch fed is determined by four factors: the size of the feeder, the length of the pusher stroke, the number of pusher strokes per minute, and the length of the feeding time.

Triangular doghouse with both feeders in place. In this particular installation the batch reaches the feeders through pipe chutes. These are provided with control gates in case it is desired to remove the feeders, as for rebuilding the tank. In case of a unit batch delivery system, such as a tramrail, the chutes are replaced with a different type of batch receiving arrangement. Notice that there is no sting out, even though the furnace is operating at full melting temperature.



Rear view of one of the batch feeders, showing the pusher. Note the two small piles of batch which were formed, when the feeder was first put into operation. At this time the batch flows over and around the pusher to form the seal. The motor is ½ h.p., which is all the power required to operate this 18 inch feeder—the size selected for this 50 ton tank.



The control panel. The lower row of instruments is made up of timers which are usually set to control automatically the operation of the feeders. Above are switches and signal lights, the latter indicating to the operator at all times the stage of the operating cycle.

Complete mixed batch is supplied to the receiving chutes of the feeder by gravity or by conveyors. It is pushed from the feeder into the doghouse by a curved pusher (see photograph, page 55), which reciprocates about the center of its curvature. Springs and circuit breakers provide the proper resiliency and protection in case anything should interfere with the movement of the pusher.

A fixed number of strokes per minute for the pusher is provided by a speed reduction unit. The length of stroke of the pusher or rate of fill is regulated by means of a hand-operated adjusting screw which varies the position of the vertical connecting rod in the pusher actuating lever segment. A scale is provided on the pusher lever segment for reading the position of the connecting rod.

Approximately 29 strokes per minute with a movement of 1⅛" to 2¼" is the normal working range of the feeder pushers. Within this range of adjustment, high

(*Continued on page* 80)

SETTINGS IN MINUTES OF BATCH FEEDER RUN & DELAY TIMERS
15 MIN. FIRING PERIOD - FURN. #1 - GLASS CO.

TABLE #9 A — EACH FEEDER WITH 1⅛" LENGTH OF STROKE; R.H. FEEDER FOLLOWED BY L.H. FEEDER

RATE OF PULL IN TONS PER 24 HRS.	RIGHT FEEDER #1	RIGHT FEEDER #2	BOTH FEEDERS #3	BOTH FEEDERS #4	LEFT FEEDER #5	LEFT FEEDER #6
25	2⅞	3⅛			9⅝	3⅛
24	2¾	3			9¼	3
23	2¼	2⅞			9¼	2⅞
22	2⅜	2¾			9⅛	2¾
21	2⅛	2⅝			9⅛	2⅝
20	2½	2½			10	2½
19	2½	2⅜			10	2⅜
18	2⅜	2¼			10⅛	2¼
17	2⅜	2⅛			10⅛	2⅛
16	2¼	2			10¼	2
15	2¼	1⅞			10¼	1⅞
14	2⅛	1¾	NOT		10⅛	1¾
13	2⅛	1⅝	IN		10⅛	1⅝
12	3	1½	USE		10½	1½
11	3	1⅜			10½	1⅜
10	3⅜	1¼			10⅝	1¼
9	3⅜	1⅛			10⅝	1⅛
8	3¼	1			10¾	1
7	3¼	⅞			10¾	⅞
6	3⅛	¾			10⅞	¾
5	3⅛	⅝			10⅞	⅝
4	3¼	½			11	½
3	3¼	⅜			11	⅜
2	3⅝	¼			11⅛	¼
1	3⅝	⅛			11⅛	⅛

BASED ON CAPACITY OF ONE FEEDER WITH 1⅛" STROKE, FEEDING CONTINUOUSLY, FOR PULL OF 60 TONS/24 HOURS — DEC. 9, 1940 A.S.C. W.

SETTINGS IN MINUTES OF BATCH FEEDER RUN & DELAY TIMERS
15 MIN. FIRING PERIOD - FURN. #1 - GLASS CO.

TABLE #9 B — EACH FEEDER WITH 2⅛" LENGTH OF STROKE; R.H. FOLLOWED BY L.H. FOLLOWED BY BOTH

EACH FEEDER WITH 1⅛" LENGTH OF STROKE; R.H. FOLLOWED BY L.H. FOLLOWED BY BOTH

RATE OF PULL IN TONS PER 24 HRS.	RIGHT FEEDER #1	RIGHT FEEDER #2	BOTH FEEDERS #3	BOTH FEEDERS #4	LEFT FEEDER #5	LEFT FEEDER #6
50	¾	2⅝	3⅞	½	7¼	2⅝
49	⅞	2⅝	3⅞	½	7⅜	2½
48	⅞	2½	3⅞	½	7⅜	2½
47	⅞	2½	4	½	7⅜	2⅜
46	⅞	2⅜	4	½	7½	2⅜
45	⅞	2⅜	4	½	7⅜	2¼
44	1	2¼	4	½	7⅜	2¼
43	1	2¼	4⅛	½	7⅜	2⅛
42	1	2⅛	4⅛	½	7½	2⅛
41	1⅛	2⅛	4	½	7½	2
40	⅝	4	2⅛	1	7	4
39	⅝	3⅞	2½	1	7	3⅞
38	⅝	3¼	2⅝	1	7	3¼
37	⅝	3⅛	2⅝	1	7	3⅛
36	¾	3⅝	2¾	⅞	7⅛	3⅝
35	¾	3½	2⅞	⅞	7⅛	3½
34	¾	3⅜	2⅞	⅞	7⅛	3⅜
33	¾	3¼	3	⅞	7⅛	3¼
32	¾	3¼	3⅛	¾	7⅛	3¼
31	¾	3⅛	3¼	¾	7⅛	3⅛
30	⅞	3	3¼	¾	7⅛	3
29	⅞	2⅞	3⅜	¾	7⅛	2⅞
28	⅞	2¾	3½	¾	7⅛	2¾
27	⅞	2¾	3⅝	⅝	7¼	2¾
26	⅞	2⅝	3⅝	⅝	7¼	2⅝

BASED ON CAPACITY OF ONE FEEDER WITH 1⅛" STROKE, FEEDING CONTINUOUSLY, FOR PULL OF 60 TONS/24 HOURS — DEC. 9, 1940 A.S.C. W.

A chart showing typical settings of the timing dials as calculated for a particular tank. When the tank operator receives instructions as to the rate he should pull his tank, he reads across the line of that particular tonnage and sets the dials on his control panel accordingly. Just that complicated, and no more. It will be noted that the settings here do not correspond with either of the examples quoted in the text, since in the chart the time intervals shown are cumulative in some cases.

THE PHYSICS OF UPWARD DRILLING

By F. W. PRESTON and J. C. TURNBULL

One of the most interesting discussions at last summer's meeting of the Glass Division was that revolving around Dr. Preston's demonstration of "Upward Drilling." Since the Hershey meeting, Dr. Preston has prepared a paper on this subject which has just appeared in the February number of the American Journal of Science. Through the courtesy of the publishers, *The Glass Industry* presents here the substance of this paper, omitting much of the mathematical detail.

The fact that downward-facing surfaces of refractory in a glass melting furnace commonly become deeply pitted has been observed for many years. Such surfaces are for instance the "rings" and "floaters" which act as barriers to the movement of scum and floating particles. The same is true of the lintel block of a tank throat. And because the corrosion on downward-facing surfaces is not only pitted but rapid, it became standard practice some 20 years ago to make the tank walls in a single course of blocks, so as to avoid horizontal joints, which must necessarily provide at least one downward-facing surface. Where there is no means of avoiding such a surface, as in the throat of a tank, for instance, there was provided the first generally accepted location for "super-refractories" in tank construction.

The practical importance of the matter is well attested by the design of about every glass tank in the country, but the literature on the subject is very scanty. The mechanism that brings about the pitted conditions has been generally called "upward drilling" and has been investigated by McCauley[1] and Ross[2]. McCauley recognized that at the top of an upward drilling cavity there was a gas bubble, and that the bubble was an essential part of the mechanism; McCauley further recognized that surface tension played an important part in this and some other forms of refractory corrosion.

As a rule the pits are not deep, because as a number of holes drill upward in relatively close proximity, the intervening ridges, surrounded on all sides by solvent glass, also dissolve away, and the stable configuration seems to be one with pits whose depth is comparable with their diameter (See Fig. 1). With reasonably homogeneous blocks, all the pits have comparable depths, and one pit is not vastly deeper than another. Moreover, all the pits are of comparable diameters, about big enough to stick one's thumb into. There must, therefore, be some definite mechanism regulating the size of the bubbles responsible for the drilling, or causing a particular size of bubble to be most effective. This observation caused one of the present writers (F. W. P.) a good many years ago to begin experiments with "models" made with transparent liquids and solids, to find out what the mechanism was.

The first "model" proved to be very fortunate. The solid chosen was ice. The liquid was a mixture of alcohol and water adjusted to the same density as ice. The experiment was carried out below zero centigrade, in order that the ice should "melt" only by chemical attack (solution) and not by heat. The ice was supported over a beaker with its lower, downward-facing surface immersed in the liquid. It was immediately observed that tiny bubbles formed and danced agitatedly up and down below the ice, and started to drill upward. As time went on, the bubbles increased in size, and the pits increased in diameter, till they were perhaps of the order of 1/16″ across, but they did not increase beyond this size (See Fig. 2). This seems to be the stable scale of operations for this particular combination of substances, and it is a much smaller scale than obtains with molten glass and tank blocks. After trying various other materials for experiment, it became apparent that upward drilling in ice did not take place in the absence of bubbles, and that the size of the holes depended on the size of the bubbles, and that there was some size of bubble and hole that was most active and therefore most stable.

The possibility that "upward drilling" on the earth's crust may be the explanation of volcanoes should not be overlooked; but a volcano vent is much larger in diameter than the 1″ holes in a tank block, and if it can be accounted for in the same fashion, the physical quantities involved must be numerically quite different.

The experimental work consists in investigating the behavior of bubbles by direct observation, a thing which cannot be done with molten glass. The behavior of bubbles of various sizes and of different gases was examined and the various fluids were investigated to see what combination of physical properties was necessary for upward drilling to start and continue. The observations, therefore, differ considerably from those reported hitherto, which concern the appearance of refractories after removal of glass from the furnace, or after removal of refractories from the tank.

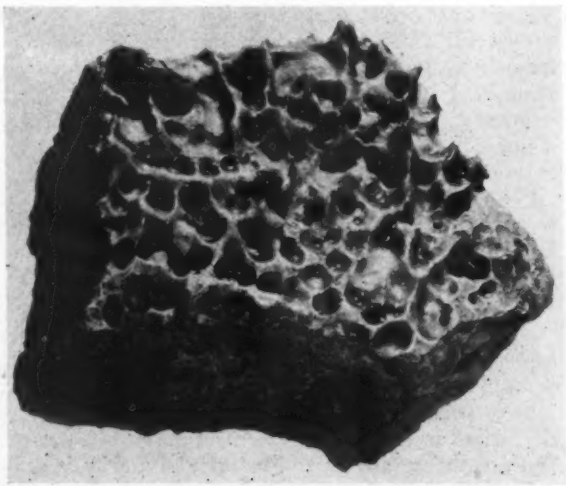


Fig. 1. Appearance of the downward-facing side of a refractory block, after its removal from a glass tank. The pitted condition of the surface is caused by upward drilling. A gas bubble would be found in each of the pits in this surface, before removal of the surrounding glass.

[1]McCauley, G. V.: Discussion in "Symposium on Glass Industries Refractories," Bull. Am. Cer. Soc. 4, 605, 1925.
[2]Ross, D. W.: Jr. Am. Cer. Soc. 9, 641, 1926.

Fig. 2. Appearance of the downward-facing side of a piece of ice, after attack by upward drilling gas bubbles, and after its removal from the alcohol solution.

The limitations of the experimental work made it advisable to formulate a mathematical treatment.* A degree of agreement between theory and observation was obtained for several cases of practical interest.

Upward drilling represents an acceleration in the rate of solution of a solid, in which some of the available mechanical energy is used to increase the rate of solution. The rate of drilling depends on a number of the physical properties of the materials involved, particularly on the changes in some of these properties as the solution is diluted by the dissolving solid. Variations in surface energy of the bubble during drilling represent the most important of these; the surface of a bubble absorbs the component of a solution which lowers surface tension, and upward drilling may occur if this component helps dissolve the solid. In particular, it seems that the surface tension forces are primarily responsible for the characteristic motion of gas bubbles while they are drilling upward. Accordingly, the composition of the gas in the bubble is not of much consequence, since the nature of the gas above a liquid surface has little effect on its surface energy.

At least two forces act on a bubble moving about in a liquid of varying composition; the gravitational force, and the force caused by variations in surface energy. In a static liquid, the latter force has a potential, given by the surface energy, $\Delta\gamma\sigma$, where γ is the surface tension, and σ is the surface area. The force of gravity is ordinarily the most important one for the bubble, but it can be overbalanced by the other force which is given by the gradient of surface energy. This happens during upward drilling at the lower ice surface, for example, in the case of ice attacked by alcohol, and it is clear that there is a large gradient of alcohol concentration, and hence of surface energy, at this part of the liquid.

During upward drilling of gas bubbles in alcohol solutions on ice, small bubbles are continuously jumping downwards from their position in contact with the lower ice surface, where the concentration of alcohol is least, to some distance from the ice, where the concentration of alcohol approaches its mean value for the solution. In moving from pure water to an alcohol solution, a bubble loses surface energy $\Delta E = \Delta\gamma\sigma$, where $\Delta\gamma$ is the difference in surface tension of water and of the alcohol solution. This may appear as mechanical energy, and it could then push the bubble downwards a distance h, where mgh is the energy required, neglecting viscosity, and m is the mass of fluid displaced by the bubble. $\frac{\Delta E}{mg}$ is therefore an upper limit for h. For a solution of alcohol in water, $\Delta\gamma$ might be 30 dyne/cm., and a bubble of radius 0.1 mm. could be moved 9 cm. downwards. Small bubbles in alcohol solutions do not move as much as this, however, because of the viscosity of the solution, the effect of which was considered in the mathematical treatment.

Ordinarily, a solid dissolving in a solution is surrounded by a layer of liquid different in temperature or composition from the solution itself. If a bubble is to accelerate attack on the lower face of the solid, it must carry material through this small region next to the solid surface. The surface energy of a bubble when it is immersed in the region near the solid must therefore be higher than when it is surrounded by solution some distance from the solid. The difference in surface energy, $\Delta\gamma$ is a measure of the mechanical energy which the bubble receives from surface tension forces. $\Delta\gamma$ may be estimated if the surface energy of the solution involved is known; with ice, water, and alcohol, for example, the surface tension change is approximately the difference between the surface tension of water and that of the alcohol solution.

The physical mechanism of attack by upward drilling

Fig. 3. Downward view through ice of small bubbles drilling upwards on the lower ice surface in an alcohol solution. The edges of the pits shown are visible as approximately circular lines, and the gas bubble responsible for each hole can be seen in the interior of this circle.

*See complete paper.

Fig. 4. Rock salt crystal after attack by water, showing the downward facing surfaces. The formation of gas bubbles on the lower surface during attack results in a pitted condition of this surface, which is similar to that observed on ice and refractory blocks.

bubbles thus seems to be one in which the bubble, initially at rest on the downward-facing surface, picks up the material which lowers its surface energy, jumping downwards off the surface as a result. It may thus reach more concentrated solutions further from the ice. Finally, having absorbed all it can of the material which lowers surface tension, it is forced by gravity back up against the solid surface, carrying this material with it. Here it can release the material, which is diluted by its attack on the solid, and the surface energy of the bubble returns to its initial value.

The following conditions necessary for the existence of upward drilling are therefore suggested:

1) The density of solution and dissolved solid must be greater than that of the solution alone, otherwise action will stop when a relatively small amount of the solid has been attacked.
2) The surface tension of the solution must be appreciably increased by the solution of the solid.
3) The component of solution absorbed by the surface of the bubble, which is responsible for its lower surface tension, must be of some help in dissolving the solid; in the case of ice, it should form a freezing mixture with ice and water, i.e., it should lower the freezing point of the solution.

The importance of these conditions has been confirmed by observation on upward drilling on ice in liquids of verying specific gravity and surface tension.

We have so far discussed the behavior of small bubbles. Larger bubbles have a similar effect on ice, but they do not leave its lower surface. In drilling on ice, irregularities in the solid surface above the bubble are filled with liquid, so that the upper surface of the bubble is approximately flat. Attack by the bubble proceeds upwards and sideways, smoothing out the surface irregularities, and forming a cylindrical hole larger in diameter than the bubble, in which drilling is accomplished by rotation of the bubble about the center of the hole (See Fig. 5). In alcohol solutions, attack by these larger bubbles is slower than by smaller ones, and bubbles of diameters of about one mm. are most effective in drilling.

As with smaller bubbles, which jumped downwards off the ice when absorbed alcohol was removed, the motion of the larger bubbles results from the tendency of the surface to lower its energy by absorbing alcohol; but in this case, motion is horizontal instead of vertical. This motion is also partly due to the formation of liquid above the bubble, which accumulates there as the bubble attacks the ice. With very large bubbles drops of liquid may form above the bubble and eventually fall through it before it moves. These large bubbles, however, are unstable, showing a tendency to break up into smaller ones, particularly on a plane surface, and their rate of attack is very low.

Because of flattening of the bubble against the ice, the area of the capillary film between the ice and the bubble increases rapidly as the size of the bubble increases. This film will freeze if the ice is cold enough and the bubbles are large enough. At ice temperatures somewhat below freezing, for example, 20° F., even moderately sized bubbles freeze to the ice, and the general solution of the ice proceeds around it. Liquid pockets no longer form in cavities above the bubble, and, since there is no capillary film above the bubble, there is no transportation of alcohol to this area, and no upward drilling. The temperature of the ice, however, has no effect on the behavior of small bubbles, which drill upwards as fast on cold ice as on warm.

It should be noted that flux-line attack, in which the solid dissolves rapidly at the meniscus of the free liquid surface on the solid, is to some extent another manifestation of the phenomenon observed in upward drilling. Ice floating in alcohol is subject to flux-line attack, and it assumes the characteristic shape caused by this attack.[3] Solution proceeds rapidly at the meniscus, since alcohol is brought to this point by the variations in surface energy, and alcohol is removed continuously by melting ice at this point.

Calculations have been made of the motion of a bubble, taking the viscosity of the liquid into account. These indicate that there is a bubble of maximum activity, for given change in surface energy ($\Delta\gamma$) and viscosity of liquid, and the calculated radius of the most active bubble was compared with those observed in up-

(*Continued on page* 65)

[3]Preston, F. W.: Bull. Am. Cer. Soc. 15, 409, 1936.

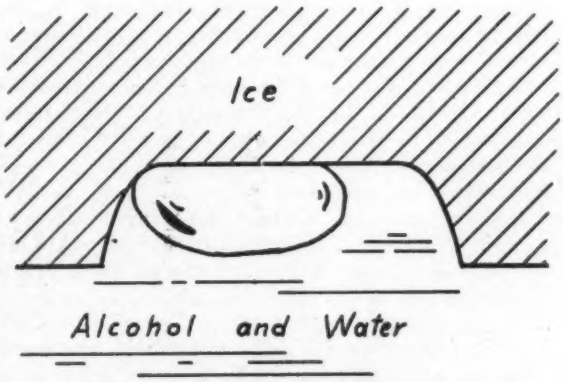


Fig. 5. Side view of a large bubble drilling upwards in ice. The top of the bubble flattens, and it drills by moving in a circle around the edge of the hole, always keeping in contact with the ice.

A. C. S. MEETING AT BALTIMORE

Program of the Glass Division meeting, with titles of papers, plant trips and other details of interest.

As April draws near, interest of glassmen and ceramists is focusing on the city of Baltimore, where the forty-third annual meeting of the American Ceramic Society will open March 30 and continue through April 5.

Scanning the tentative program arranged by a large and energetic committee of nearly forty members, one finds that the customary traditions have all been followed—faithfully, but by no means slavishly; for this year some innovations have been introduced into the familiar convention pattern. Among the latter is a general luncheon on Monday noon, in which members of all the Divisions will participate. There will be a speaker, and community singing. Another event appearing for the first time is a Student's Reception, to be held Wednesday night, where a band will play college airs, and a song leader will extract the maximum in harmony from the student voices. Plant trips, formerly a high light of these meetings, but dropped in recent years in cities where facilities were not available, have been resumed. Visits will be made to Carr-Lowrey and to Maryland Glass Corporation on Thursday morning, and that same afternoon a very special treat is in store—a visit to the Calvert distillery at Relay, Maryland. This plant is considered the very last word of super excellence in distilleries.

The meeting will open officially with a tea on Sunday afternoon. Though designated officially as a Ladies Tea, the men are invited; in fact, are expected. Sunday night there will be a big Open House in the Ball Room of the Lord Baltimore, with dancing and entertainment from nine to one. The B & O Glee Club, a celebrated magician and a charming songstress are but three items on the program that so far has not been entirely completed. Admission to this evening of gaiety is included in the registration fee.

But the BIG night will be Tuesday, which significantly enough is April the first. Its official designation is "A Night on the Chesapeake." Entrance to the Chesapeake is gained through the Ballroom of the Lord Baltimore. After a pleasant sail down the Bay, the boat anchors at one of the oyster beds, for which this body of water is nationally famous. Guests of the convention will be regaled with all kinds of seas food, coffee, and/or free beer, while they watch a nautical floor show. Admission is $1.50 per ceramist, and it will be cheap at the price.

Registration will be at the Lord Baltimore, and the fees: Members, $5.00; Students, $1.50; wives of members, $1.00. Room reservations may be made at one of the following hotels: the Lord Baltimore, the Southern, the Emerson, and the Belvedere.

The Glass Division luncheon will be held Tuesday noon, in the course of which business will be transacted and committee reports received. Technical sessions will be held on Tuesday and Wednesday. The following titles constitute the preliminary program of papers. A few others have been scheduled and will be announced before the meeting.

Tuesday Morning, April 1.

1. **Formation of Apatite in Opal Glasses and Bone China.**
   By Waldemar A. Weyl, *Pennsylvania State College.*
2. **Some New Methods of Cleaning Glass Sands.**
   By John Dasher and Oliver C. Ralston, *U. S. Bureau of Mines.*
3. **Factors Influencing Autoclave Chemical Durability Tests of Glass Containers.**
   By A. Herman, *Joseph E. Seagram & Sons, Inc.*
4. **New Uses of Pate and Window Glass.**
   By R. A. Miller, *Pittsburgh Plate Glass Co.*
5. **Phosphate Glasses and Some Characteristic Properties.**
   By N. J. Kreidl and W. A. Weyl, *Pennsylvania State College.*

Tuesday Afternoon, April 1.

6. **Tantalum Glass—K_2O—Ta_2O_5—SiO_2 Series.**
   By Kuan Han Sun and Alexander Silverman, *University of Pittsburgh.*
7. **A Method for Testing the Surface Alkalinity of Glass Bottles.**
   By A. J. Liebmann and M. Rosenblatt, *Schenley Distillers Corp.*
8. **Analysis of Gases Dissolved in Glass, and Gas in Seeds.**
   By Hugh A. Shadduck and Arthur Van Zee, *Owens-Illinois Glass Company.*
9. **Amber Glass and the Role of Carbon.**
   By Henry Moore and S. R. Scholes, *Alfred University.*
10. **Elastic Aftereffects and Dielectric Absorption in Glass.**
    By Nelson W. Taylor, *Pennsylvania State College.*

Wednesday Morning, April 2.

11. **Phosphorous Compounds as Reducing and Fining Agents for Glasses.**
    By W. A. Weyl and N. J. Kreidl, *Pennsylvania State College.*
12. **A Summary of Work on the Atomic Arrangement in Glass.**
    By B. E. Warren, *Massachusetts Institute of Technology.*
13. **Soda-Boric Oxide-Silica System.**
    By G. W. Morey, *Geophysical Laboratory.*
14. **X-ray Diffraction Studies of Some Soda-Lime-Silica Glasses.**
    By J. Biscoe, *Massachusetts Institute of Technology.*

Wednesday Afternoon, April 2.

15. **Glass Batch Mixing.**
    By Wayne E. Brownell and S. R. Scholes, *Alfred University.*
16. **Effect of Ultra-Violet Light and X-Radiation on the Color of Iron-bearing Glasses.**
    By A. E. Badger and A. Ottoson, *University of Illinois.*
17. **Conditions Encountered in the Filling of Pressure Ware.**
    By J. A. Sharf, *American Bottlers of Carbonated Beverages.*
18. **The Effect of (a) Barium Oxide and (b) Zinc Oxide, on Certain Physical and Chemical Properties of a Typical Soda-Dolomite Lime-Silica Glass.**
    Contribution of the General Research Laboratory, *Owens-Illinois Glass Co.*

• Dr. Frank L. Jones, Senior Fellow, Multiple Industrial Fellowship on optical glass, Mellon Institute, Pittsburgh, has joined the staff of the donor, The Bausch & Lomb Optical Co., Rochester, N. Y., as director of chemical research.

METAL MOLDS FOR GLASS PRODUCTS

By A. H. DIERKER
Ohio State University*

Molds and mold making have not received their due share of attention in the literature of glass making, and in general one may state that the practical mold maker has advanced his art to a degree that appreciably transcends the literature. No doubt it is because there has been so little scientific approach to the solution of mold problems, that there exist many divergent opinions and many questions are highly controversial. When Mr. Dierker's paper appeared recently in the *Engineering Experiment Station News*, it seemed particularly valuable in that it brought together into a single article many accepted facts about mold making, and it also was more than normally prolific in new thoughts, ideas and information. And so with permission of the *News*, we are making this discussion available to a wide audience of glass men through the columns of this publication.

An ideal material for glass molds would have many desirable properties chief among which would be found:

1. Uniform close grain and ability to take a high polish
2. Resistance to heat shock and "fire cracking"
3. Freedom from growth and warping
4. Good thermal conductivity
5. Ease of machining and ability to hold sharp edges
6. Moderate cost

No one material has all these properties in the right degree, and in selecting a mold material a compromise is sought that will give the best obtainable results for the job in hand.

Molds are, or have been made, of the following materials:

1. Unalloyed cast iron
2. Alloyed cast iron
3. Plain carbon or low alloy steel
4. High alloy steel
5. Plated iron or steel
6. Non-ferrous alloys

By far the bulk of the molds in use are made of unalloyed or very lightly alloyed cast iron. In making molds of this material the working face is usually cast against a "chill." This sudden cooling gives that particular part of the iron a fine-grained structure that enables it to take a high polish. Other materials find it difficult to compete with the low cost, ready availability, and ease of machining of gray cast iron.

High alloy cast irons have not shown any great promise in this field. Plain carbon and low alloy steels show a tendency to scale badly at operating temperatures and are seldom used. Among the high alloy steels the stainless steels seem to give the best promise with the plain chromium (cutlery type) steel proving quite successful for certain types of work.

Chromium is the usual material used for plating glass molds and parts. For parts such as plungers subject to unusually severe service, it has shown definite merit. Gray cast iron is usually used as a base material for the part to be plated.

Non-ferrous alloys have found little application in this field. Smith[1] has published an excellent outline of experience with various types of materials in glass molds and the requirements for this type of service.

The three chief troubles encountered in the use of glass molds are: (1) Cracking, (2) Sticking, (3) "Dirty" ware.

Cracking

As has been indicated, the molds are subject to repeated and severe thermal and mechanical stresses, particularly the former. Often, in time, these stresses start and propagate small cracks. It does not take long then for these cracks to grow large enough to make the mold unfit for further use.

The magnitude and distribution of the temperature in the mold are well worth considering from the angle of operation as well as of design.

Temperature measurements have been taken by means of thermocouples inserted in the interior of the mold body as well as at the working face and the outside surface. The set up did not permit simultaneous readings within a small enough time limit to secure an accurate picture of temperature distribution. However, the results did give some quite interesting indications:

1. The temperature of the working face of the mold often exceeded 1000°F.
2. The temperature at any one point varied quite rapidly in a regular cycle, each cycle corresponding to the production of one piece of ware.
3. Temperature peaks and minimums were not reached at the same time at different points nor were the temperature changes always in the same direction, i.e., they could be falling in one part of the mold while rising in another part.

It is well to keep in mind that it is not the maximum temperature at which a mold operates which causes it to crack so much as it is the maximum temperature difference reached between various parts of the mold body and the rate of change of temperature at any particular point.

Materials of low thermal conductivity will naturally show greater temperature differences and hence are more prone to crack in use.

In the case of cast iron another factor must be considered. At the operating temperatures of the mold, at least those reached at the working face, gray cast irons of usual composition have a strong tendency to "grow" i.e., show a permanent increase in volume. Such permanent "growth" undoubtedly sets up stresses which, when they occur in addition to the usual thermal stresses, may easily cause the mold body to crack.

Resistance to cracking by "heat shock" can be increased in gray cast iron by using a high carbon material. The larger and more numerous graphite flakes in the iron matrix seem to give a cushioning effect. In the steel industry the use of high carbon iron with coarse graphite flakes is fairly well established practice for ingot molds and pig molds where the heat shock is quite severe.

However, large and numerous graphite flakes give an "open" structure to the iron, so that a smooth, highly polished surface is impossible. Hence in the manufacture of glass molds it becomes a nice problem to produce a metal structure sufficiently "open" to prevent cracking and still "close" enough to take a reasonably high polish.

If freedom from cracking is to be achieved, perhaps

*Research Engineer, Engineering Experiment Station.

[1] R. D. Smith, "Metallurgical Needs of the Glass Industry," *Metals and Alloys*. Sept. and Oct., 1936, pp. 217-220; pp. 263-266.

more important than the material of which a mold is made are the design and the conditions under which the mold is operated. Unfortunately little study seems to have been made of mold design and it appears common practice to leave operating conditions to the discretion of the machine operator.

There is little doubt, too, that immediately after being cast, iron castings contain internal strains that may persist for a long time. We would expect this to be particularly true of "chill" cast molds where one part of the casting is cooled at a much more rapid rate than another. Although it is not general practice, it would seem advisable to give all molds a stress relief treatment before any machining operation. Heating to 900°-1200° F. should be sufficient for this purpose

Sticking

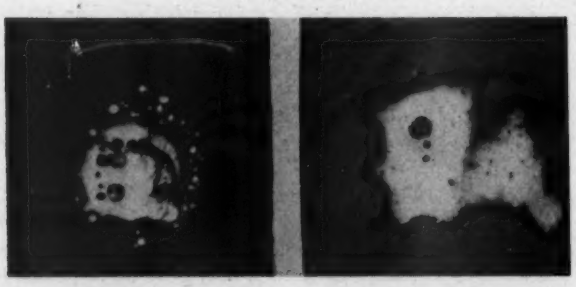
Under certain conditions the hot glass will stick to the metal surface of the mold. It is impossible, under such conditions, to produce satisfactory ware. Sticking must be avoided at all costs.

Not only will the glass stick to the mold surface as the temperature of the surface rises but will stick more readily where there is a direct glass to metal contact than where something intervenes. Hence the usual practice is not only to control the temperature of the mold but also to keep the surface coated with some foreign material that prevents direct contact between glass and metal. Such materials are, for some unknown reason, called "lubricants."

A large number of materials have been and are constantly being tried out as lubricants. Nothing seems to have proved universally satisfactory. Generally the materials that leave a "sooty" or carbonaceous deposit have found the most extended use. For example, light mineral oil may be dropped in the hot mold after the formed ware has been removed. The heat of the mold, being above the flash point of the oil, causes it to "flash" with the decomposition of some of the hydrocarbons, thus leaving a deposit of carbonaceous material on the mold surface.

Rubber rubbed on hot mold parts leaves a deposit that helps to prevent sticking.

There is little published information available on means of preventing sticking and apparently no fundamental studies have been made on this subject. However, the adherence of glass to metals is of prime importance in certain large industries, such as those engaged in coating iron and steel products with vitreous (glass) enamels, and much study has been given to this type of work.



Spec. 5-2 Poor wetting — Spec. 6-2 Good wetting

Fig. 1. Ability of glass to wet the surface of cast iron as modified by the surface treatment of the metal.

Since the literature on the adherence of glass to metal, particularly iron and steel, is rather extensive, an examination of this literature might well prove helpful in our study of glass molds. If, from a study of this literature, we can learn the fundamental reasons why glass sticks to metal, then we may be able to develop means of preventing such adherence. Knowledge of sticking may help in "unsticking."

Enamels and Glasses

Enamels for coating iron and steel are glasses although admittedly of a special variety. Numerous theories have been advanced for explaining the adherence of enamels to iron and steel, but the most reasonable and widely accepted is the oxide theory.

In 1924, Cooke[2] published some fundamental observations on the importance of oxygen in the enameling process. He used a carbon combustion furnace, in which the atmosphere could easily be controlled, and applied an ordinary enamel to small steel samples under various conditions. He found:

1. Firing in static air of the chamber gave a blistered coat. If air was flowing slowly adhesion was perfect.
2. It was only necessary to have air flowing during an interval of 15-20 seconds after the piece was introduced.
3. In an atmosphere of nitrogen the enamel rolled into balls, but if the piece was first oxidized at 750° and then enameled in nitrogen, the coat was normal.

These observations indicate that enamel does not adhere to clean steel but that an oxide film is needed to cause wetting. Cooke considers that the oxide layer is partly dissolved in the glass, thus forming a transitional zone from enamel to metal.

Other investigators, particularly Dietzel and Meures (10) have investigated this matter further and confirmed Cooke's views. Investigators in enamels are concerned with two problems, wetting of the surface and permanent sealing. In the case of glass molds we are concerned only with initial wetting. If that can be prevented there is no problem of "sticking." Taylor[3] has investigated the matter of wetting in particular and points out that metal glass seals are not mechanical but chemical in nature. When dissimilar materials are to be joined a transitional zone having to some extent the properties of both materials is necessary. Many metals form adherent oxide layers which are soluble in glass to varying excess, such oxide layer acting as the transition zone. Taylor investigated the effect of oxide additions of various kinds on the wetting properties of glass enamels and classified these oxides according to their ability to increase the wetting ability of the enamel as follows:

Sb_2O_5, Fe_2O_3 } Good Wetting — Cr_2O_3, BaO_2 } Poor

CoO, NiO, MnO, Sb_2O_3 } Intermediate

In studying glass molds we are primarily concerned with the prevention of wetting. Accordingly, some tests were made of the tendency of glass to stick or wet the surface of cast iron treated in various ways.

[2] R. D. Cooke, "The Effect of Furnace Atmosphere on the Firing of Enamel," *Jrl. Am. Ceramic Soc.* I, 266 (1924).
[3] Nelson W. Taylor, "The Adherence of Glass to Metals," *Glass Industry*, 16, 243 (1935).

Mold Wetting Tests

Test pieces 1¼ in. square by ¼ in. thick were cut from a single bar of cast iron. An analysis of the iron showed

Total carbon	2.77 per cent
Silicon	2.42 per cent
Manganese	.47 per cent

The iron pieces were given various treatments, as indicated in Table I.

A powdered glass known as Cramer's frit was selected for the test. This frit has a softening range near 750° C and its composition in molecular ratio is $2SiO_2$, $1B_2O_3$, $0.5CaO$, $0.5Na_2O$. One gram of frit was placed on each piece of iron.

The test specimens were then put into an electric furnace for 45 minutes. During this period the temperature rose from 690° to 860° C and the glass fused completely.

Table I reports the general appearance of the specimens after firing and cooling. Fig. 1 pictures two of the fired specimens, one showing good and the other poor wetting. Since the phosphate treatment showed promise, several specimens were given a commercial phosphate (rust proofing) treatment. These specimens gave similar results to the laboratory treated specimens. Tests under actual operating conditions would be desirable.

It is unlikely that any pre-service treatment of the mold surface would be effective in preventing wetting unless the desired surface could be maintained. By initial treatment the trouble due to sticking probably would only be delayed, not overcome.

"Dirty" Ware

Of the three major troubles encountered in the use of glass molds the problem of "dirty" molds seems to be the most complex and most pressing. For the purpose of this discussion we are assuming a "dirty" mold to be one which produces ware with such a rough or discolored surface that subsequent "fire polishing" will not produce a commercially satisfactory product.

A brief explanation of "fire polishing" may be in order. The ware, as it leaves the mold, has a relatively rough surface which might be described as a matte surface, shown in magnified form in Fig. 2A. From the mold the ware passes to a polishing machine where it is subjected to the direct flame of a number of gas burners. The heat of these burners quickly softens the surface of the glass sufficiently to permit it to smooth out. Then, before the entire body of the ware has time to soften up and deform, it is passed from the polishing machine to the annealing lehr. The surface of the properly polished ware is shown in Fig. 2B.

When the molds are "dirty" the glass surface will not "polish" smooth and we get finished ware that may look like that in Fig. 2C. Ware of this type, of course, must be scrapped.

There are two major causes for "dirty" ware:

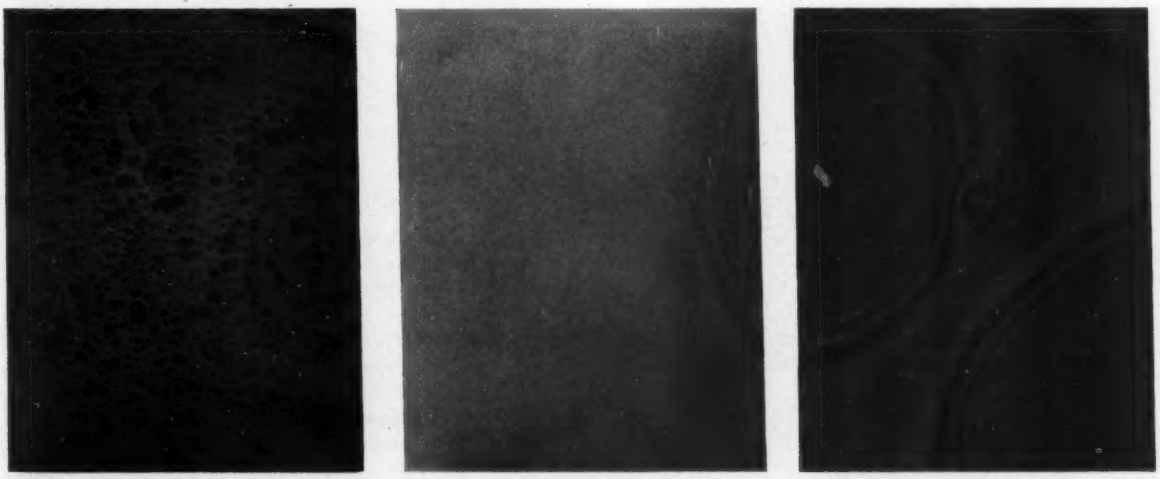
1. Deterioration of the metal at the working surface of the mold.
2. Accumulation of foreign material on the working surface.

TABLE I

TENDENCY OF GLASS TO STICK TO CAST IRON WITH VARIOUS TYPES OF SURFACE COATINGS

Spec. No.	*Treatment*	*Results*
2-1	Oxide coating produced by superheated steam and reducing gas (Bower-Barff process)	The main body of glass cracked off leaving its bottom portions tightly held
2-2	Same as 2-1 but oiled after oxidizing	The glass bottom cracked off bringing oxide coating with it and leaving iron bare
3-1	Treated with aluminum powder and ammonium chloride (calorized) scrubbed with pumice and oiled	Same as 2-1
3-2	Same as 3-1 but polished with 000 paper before oiling	Same as 2-2
4-1	Black oxide produced by treatment with molten nitrate	Same as 2-1
4-2	Same as 4-1 but oiled	Same as 2-2
5-1	Treated with phosphate to get surface coat of iron phosphate	Glass showed little tendency to spread or wet the surface. Portion rolled up into balls (See Fig. 1, Spec 5-2)
5-2	Same as 5-1 but oiled	Same as 5-1
6-1	Furnace oxidation to get normal oxide film	Strong tendency to wet the surface and spread. The glass held tightly as in enamel ware
6-2	Same as 6-1 but oiled	Same as 6-1

(*Continued on page* 81)



A. Before polishing **B. After polishing** **C. Ware from dirty mold after polishing**

Fig. 2. Micographs of surface of pressed glassware, 65x.

CONCERNING THE DEFINITION OF GLASS

A recent news item* indicates that at least one of the many lexicographers has taken recognition of the fact that we are living in the Glass Age. As a result, the latest edition of Webster's unabridged dictionary is said to contain several hundred definitions of words and terms that are common to the glass industry.

This formal recognition of the colorful language of the glass house, even though it is much belated, is highly commendable, especially when it is considered that its beginnings antedate the alphabet. It is unfortunate, however, that the definition of the material with which the glass industry works and which is commonly known as "glass" has not been modernized by the lexicographer and made to conform with the views as expressed by our present day glass technologists.

That the definition of the word "glass" as given by the various dictionaries and reference books is out of step with the word "glass" as defined by our scientific workers becomes evident when the two are compared. This is illustrated by the following definitions taken from a representative group of dictionaries and reference books.

1. "The Century Dictionary," 1889. "A substance resulting from the fusion of a combination of silica (rarely boric acid) with various bases. It is usually hard, brittle, has a conchoidal fracture and is more or less transparent, some kinds being entirely so. . . . Glass is an inorganic substance . . . but some organic substances are called vitreous."

2. "Webster's International Dictionary," 1907. "A hard brittle, translucent and commonly transparent substance, white or colored, having a conchoidal fracture, and made by fusing sand or silica with lime, potash, soda or lead oxide."

3. "The New Students Reference Work," 1923. "Glass is a combination of silica with two or more alkalies, alkaline earths or other oxides, as lime or soda. In its ordinary state glass is a solid body with a luster, is more or less brittle, and is commonly transparent."

4. "American Oxford Dictionary," 1927. "A substance usually transparent, lustrous, hard and brittle made by fusing sand with soda, potash, etc."

5. "Webster's Collegiate Dictionary," 1928. "A hard, brittle, and commonly transparent amorphous substance made by fusing together some form of silica, as sand, an alkali, as potash or soda, and some other base, as lime or lead oxide."

6. "Encyclopedia Britannica," 14th Ed. 1929. "Glass, a hard substance usually transparent or translucent which from a fluid condition at a high temperature has passed to a solid condition with sufficient rapidity to prevent the formation of visible crystals. Glass consists primarily of a combination of silica acid with an alkali."

7. "Lincoln Library of Essential Information," 1934. "A hard non-crystalline artificial substance usually transparent or translucent made by melting together various materials."

8. "Webster's New International Dictionary," 1935. "An amorphous substance, usually transparent or translucent, consisting ordinarily of a mixture of silicates, but in some cases of borates, phosphates, etc.".

9. "New Standard Dictionary," 1937. "A fused mixture of silica, usually in the form of natural sand, and two or more alkaline bases such as soda, lime or potash. It is generally transparent or translucent, is brittle and sonorous at ordinary temperatures and when heated becomes soft and ductile, finally melting. The point of fusion varies with its composition. It breaks with a conchoidal fracture, and is acted upon by hydrofluoric acid but not by ordinary solvents."

10. "Practical Standard Dictionary," 1937. "A compound of silica with metallic oxides, usually transparent and brittle."

11. "Macmillan's Modern Dictionary," 1938. "A hard, brittle usually transparent but sometimes translucent or opaque substance made by fusing a mixture of silicates (including aluminates, borates, phosphates, metallic oxides, etc.)."

12. "Van Nostrand's Scientific Encyclopedia," 1938. "Glass is defined as a liquid whose rigidity is great enough to enable it to be put to certain useful purposes."

While no attempt was made in the above survey to trace back earlier editions of either the "Century" or "Webster," it is obvious that nearly all of the definitions given in the dictionaries and reference books, from at least the year 1889 to the present, have a common origin. Most of the definitions are essentially the same, differing mainly in the phrasing used. It is also interesting to note the extent that those definitions which are found in the abridged dictionaries have suffered through their abridgement. Definition 10 is an example of excessive condensation.

A very complete criticism of the definition of "glass" as given by the 1914 edition of the "Century," the 1932 edition of the "Standard" and the 1935 edition of the "Webster's New International" has been presented by Morey (G. W. Morey, "Properties of Glass," Reinhold Publishing Company, 1938) and the present criticism must of necessity follow his line of reasoning.

Definitions 2, 3, 4, 5, 9, and 11 all neglect to include the fact that there are many one-component glasses, the best known example being silica glass. Likewise, many of the definitions, especially 3, exclude the two-component glasses such as the sodium silicates. The use of the word "artificial" in definition 7 excludes the natural glasses of which obsidian is the best known example. This definition also implies that any molten material or mixture of materials will result in the formation of glass.

In 6 the opals and other such opaque glasses are excluded by the statement regarding the visible crystals. It is true, of course, that the crystals in opal glass, for example, are not glass but the fact remains that the matrix is glassy and the lack of transparency is only due to the crystals which are suspended in the glassy matrix. The inclusion of transparency as a characteristic of glass in many of these definitions excludes many of the opals and other opaque glasses, including those colored glasses whose density of color is so great that they appear black or opaque.

As Morey has pointed out, all of the above definitions, with the exception of 12, neglect to bring out the essential continuity of condition from the fluid melt at high temperatures to the rigid glass at ordinary temperatures.

*THE GLASS INDUSTRY, August 1940, page 367.

Morey has corrected this omission by defining the material "glass" as follows: "A glass is an inorganic substance in a condition which is continuous with, and analogous to, the liquid state of that substance, but which, as the result of having been cooled from a fused condition, has attained so high a degree of viscosity so as to be for all practical purposes rigid."

Definition 12 seems to be both a revamping and an abridgement of Morey's definition. A literal interpretation of the result would mean that at the North Pole, a cake of ice if used as a table, would be classified as a glass.

Morey's definition, by the inclusion of the word "inorganic" excludes the so-called organic glasses. Moore (H. Moore, *Jour. Soc. Glass Tech.*, 23; 347, 372; 1939) defines the word "glass" as follows: "A true glass is of the nature of a liquid of extremely high, virtually infinite viscosity, which on heating, shows no sharp transition to the fluid state. It may consist of one chemical substance or of many, and at ordinary temperatures it is rigid." This definition by omitting the word "inorganic" therefore includes the so-called organic glasses. Otherwise it is very similar to that proposed by Morey.

Whether or not the so-called organic glasses should be included along with the inorganic glasses is a matter of much debate. The great majority of the so-called organic glasses, while transparent and glass-like, are formed by condensation or polymerization and not by the undercooling of fusions of the materials from which they are produced. Such materials cannot be justly included in with the inorganic glasses. There are, however, a few organic glasses that may be classed as "true glasses" inasmuch as they can be produced by undercooling from above the melting point of the material or materials. These organic glasses show reversible softening behaviour similar to that shown by the inorganic glasses. It is interesting to note that the "Century" of 1889 included such glasses by the statement "glass is an inorganic substance . . . but some organic substances are called vitreous."

It is hoped that the editors of future editions of dictionaries and reference books will seriously consider modernizing the definition of "glass" and adopt a definition such as that given by either Morey or Moore. The wide-spread mis-use of the word "glass" as applied to many of the present day organic glass-like materials should also be corrected and a proper differentiation between the true organic glasses and the organic glass-like materials should be made.

THE PHYSICS OF UPWARD DRILLING

(*Continued from page* 59)

ward drilling. In the case of attack on ice in alcohol solutions, an optimum size of 1/16″ was found for the bubble, showing good agreement with the observed values.

The change in surface tension produced by small additions of various substances to soda-lime-silica glass of average composition[4] has been measured by Badger, Parmelee and Williams[5] at 1250° C. According to these authors, the refractory materials, alumina and silica, increase surface tension, and the fluxes, which are responsible for attack, lower surface tension. Thus one per cent addition of alumina increases surface tension 2.5 dyne/cm., and one per cent addition of soda decreases it 1.5 dyne/cm. These changes are in the right direction to produce upward drilling, since there is a possibility of absorption and transportation of flux by the surface of the bubble.

If the difference in surface energy between glass very near the refractory surface and that further away from it is of the order of 20 dynes/cm., the liquid density 2 gm/cc, and the viscosity 100 poises, then the calculated value for the radius of the most active bubble is 1.4 cm. The diameter is thus about the same (one inch) as the size of the pits found in refractory blocks taken from glass tanks.

The similarity between the phenomena observed in attack on ice in alcohol solutions and on refractories in glass, in which the presence of air bubbles is necessary, and in which the corrosive component of the liquid lowers surface energy, thus indicates that changes of surface energy at the air surfaces are most important. Because of the dependence of surface energy of glass on composition, particularly with respect to the fluxes, however, it does not seem that very much can be done to dimnish this type of attack. In the case of upward drilling on ice, attack can be stopped by the addition of a wetting agent, which is adsorbed even in solutions of very small concentrations, at the surface of the bubble, and so prevents transportation of alcohol by the bubble. Whether the equivalent of wetting agents exist for glass is a question; the presence of a substance, and itself a flux, which would lower surface tension strongly, would diminish attack by upward drilling, and to some extent might reduce attack at the flux line.

[4] SiO_2, 72.5%; Na_2O, 17.4%; CaO, 10.1%.
[5] Badger, Parmelee and Williams: Jr. Am. Cer. Soc. 20, 325, 1937.

NEW LENS GRINDING MACHINE

A new machine for grinding high-grade precision lenses on a mass production basis has recently been developed by an engineer residing in Switzerland, according to a report from the American Vice Consul, Zurich, made to the Bureau of Foreign and Domestic Commerce. The inventor states that once the machine is adjusted by a skilled worker, who does not necessarily have to be a trained lens-grinder, it may be operated by unskilled workers without impairing the high quality of the finished product. He maintains that lenses ground by this method are of greater precision than those ground by previously existing methods. He also claims that lenses of this precision may be ground by his method in from 5 to 10 minutes and that polishing may be done in 4 to 10 minutes instead of the 2 to 5 hours previously required.

According to the report, Kern & Co., of Aarau, Switzerland, has purchased the rights for the sole exploitation of this method in Switzerland. The firm, which made a theoretical and practical investigation of the machine before purchasing these rights, states that the invention makes possible the manufacture by mass production methods of lenses which pass precision tests, and are accurate over the whole surface of the lens, and free from scratches and grinding marks.

DATA ON THE MELTING PERFORMANCE AND HEAT CONSUMPTION OF TANK FURNACES

By R. GUENTHER*
Frankfurt a. Main

Data for melting performance and heat requirements of tank furnaces ought to be the best numerical expression of the important operating conditions, and grounds for evaluation and comparison of different furnaces. The establishment of such data for tank furnaces is especially difficult because the operating conditions depend upon a large number of influences such as furnace construction, fuel, meltability of the batch (alkali content), cullet addition and glass quality, as well as the working temperature. The magnitude of these influences may vary between wide limits. A comparison of different furnaces is therefore possible only in the case of similar conditions. When these are different, the quantitative influence of these fundamentals on the data obtained can be estimated only approximately by evaluating them on the basis of practical results. A hard-and-fast calculation is thus far not possible.

These difficulties make it especially apparent that the comparison of different tanks must not be made still more difficult by the inclusion of a number of incongruous bits of data. It will be attempted, therefore, in what follows, to give a certain definition of the separate numerical values so that we may select the most important ones in view of the causes and effects to which their application may lead.

Selection of Data

1. *Absolute Melting Capacity.* The absolute melting performance, usually designated briefly as pull, expresses the quantity of charge melted in a given time in a furnace. As a dimension, this is conveniently expressed as t/24 hr., since the expression kg./24 hr. gives unnecessarily large numbers of four and five figures. Tons per week is only occasionally used.

The melting capacity is given for a *working day.* In control calculations on the basis of statistics, we must accordingly divide by the number of working days, not by the sum total of days.

The weight of the melted glass is the basic number in calculating melting capacity. It is reckoned as melted glass, which equals the batch addition, less melting loss, and plus cullet addition. If, as is generally the case, the level of glass is the same at the beginning and the end of a working day, the amount of glass worked out is equal to the quantity melted.

2. *Specific Melting Capacity.* The specific melting capacity expresses how much material is melted in proportion to the surface area of a furnace. Its dimension is in $t/m^2/24$ hrs. and $kg/m^2/hr$. Sometimes the entire area of the tank is taken as a value for the surface, and sometimes only the melting area or the heated area of the tank is the basis. In England and America, the reciprocal value of this number (expressed in English units) is used, that is, sq. ft./t/24 hrs. and the calculation is on the basis of melting area.

The dimension $t/m^2/24$ hr. has recently and properly gained precedence. It offers the advantage that re-calculation to the other data is more easily carried out than with the use of $kg/m^2/hr.$, since tons and 24 hr. days are also used as units for the other data.

The re-calculation follows these relations

$$1\ t/m^2/24\ hr. = 41.6/kg/m^2/hr.$$
$$1\ kg/m^2/hr. = 0.024\ t/m^2/24\ hr.$$

More important than these details of a formal nature is the expression for useful area, whether this is the entire tank area or the heated tank area, known in particular as melting area. The choice of entire tank area has the disadvantage that the influence of the different cooling effects (working temperature and the flow through the throat) enters into the specific melting capacity; for during the working processes which require lower working temperatures, a relatively large standing off area is necessary, which, in this manner of calculating, as part of the entire tank area has its effect on the specific melting capacity. In order to get away from this disadvantage, the idea of "heated tank area" and the "melting area" is introduced. In cross-fired tanks, the surface, as far as the last hot burner, is designated "heated" tank area. In tanks with horse-shore flames, a limit for the hot front cannot be chosen with certainty, and, in this type of tank, one must reckon with an area as far as the bridge wall. In tanks for the continuous pouring of cast glass, the entire tank surface is heated. These differences in types of construction make it impossible to regard the heated tank area as any well defined idea. The same is true for the idea of melting area, which cannot be limited with mathematical certainty to the working out of the melting procedure.

Since specific melting capacity is calculated from absolute melting capacity and tank area, it must have, just as these do, an average value over 24 hours. For the most part, the melting load is not distributed evenly over all 24 hours of the day. If a plant works on two shifts,

*Translated by S. R. Scholes from *Glastechn. Ber.*, July 1940, p. 185.

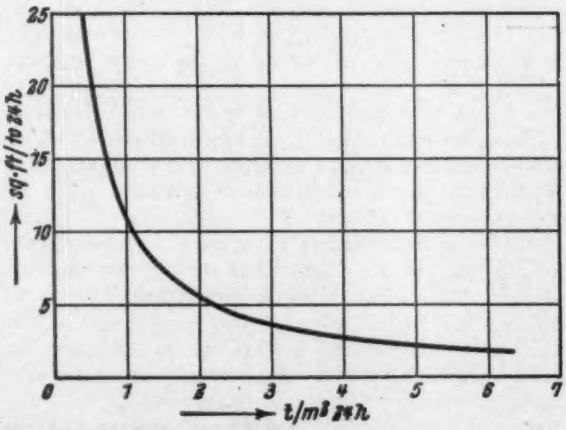


Fig. 1. Conversion curve. $t/m^2/24$ hr. ⇄ sq. ft./ton/24 hr.

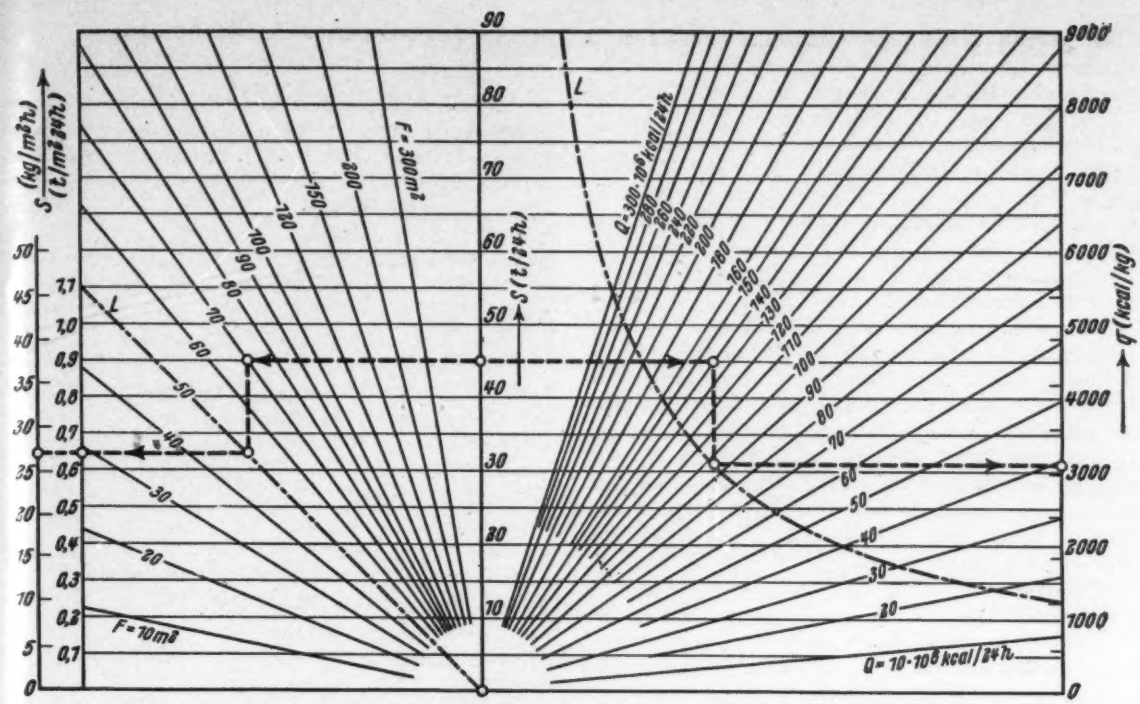


Fig. 2. Nomograph for data on melting capacity and heat requirements.
1 Ton/24 hr. = 0.9072 t/24 hr.
1 t/m²/24 hr. = 0.1024 ton/ft²/24 hr. = 204.8 lb./ft²/24 hr.
1 kg./m²/hr. = 0.2048 lb./ft²/hr.
1 kg. cal. 3.97 Btu.
1 kg. cal./kg. = 1.8 Btu./lb.

there will be less material charged during the night shift when nothing is being worked out than during either of the other two shifts. The statement of a mean value is satisfactory in such cases, as it expresses the melting capacity as an average for the 24 hours. Only for the proper calculation of some excessively high load should the pull be estimated for single hours and then, indeed, on the basis of material charged into the tank.

For the re-caculation of the English unit sq. ft./t/24 hrs., which one might designate as specific tank area, into the German unit, we have the following relationship:

$$1\ \text{t/m}^2\text{/24 hr.} = \frac{10.9}{\text{sq. ft./ton/24 hr.}};$$

$$1\ \text{sq. ft./ton/24 hr.} = \frac{10.9}{\text{t/m}^2\text{/24 hr.}}$$

1 sq. ft. = 0.0929 m². 1 ton (long ton) = 1.016 t.
[1 ton (2,000 lb.) = 0.9072 t. (metric ton, 1,000 kg.)
1 ton (metric) = 1.1023 ton (2,000 lb. ea.)]

In making these conversions, one must be very sure that in the literature of glass in English the melting area is the intended basis for calculation. Otherwise, of course, the entire tank area is intended.

Since these two sorts of data stand in a reciprocal relationship, the corresponding values lie on a hyperbolic curve (Fig. 1).

Since, in general, in glass furnace operation, the rate of pull is an important datum, it is also advisable in this case to put the expression in the form of tons/m²/24 hrs. and it must be pointed out that in this form of expression the zero value has a technical significance—it signifies the idling tank—whereas, when the reciprocal number is used as an expression, zero has no significance.

3. *Absolute Heat Requirement.* The absolute heat requirement, briefly, "heat requirement," gives the quantity of heat needed in 24 hours as tons of coal per 24 hours, normal cubic meter per 24 hrs. or kg. cal. per 24 hours. The expression in tons of coal has the advantage that it may be easily measured. It is suitable as a basis for a comparison in the midst of a run and the same is true for the expression in normal cubic meter for 24 hours for factories which use piped gas or similar fuel.

The use of a quantity of fuel as a basic figure has, however, the disadvantage that comparison with other operations is not immediately possible, since, when solid fuels are used, the efficiency of gas-generator operation comes into the picture, and, of course, the calorific value in connection with all types of fuel. One prefers, therefore, the datum kg. cal. per normal cubic meter in which (for gas-fired furnaces) the heat content of the cooled gas, taking into consideration the tar content, becomes basically important and thus arises the possibility of comparing gas, oil, and electrically heated furnaces from the point of view of their heat requirement.

If the heat requirement of a furnace must be brought into an overall calculation on the basis of the coal used, the efficiency of the gas producer may be placed at 80 per cent; or, for gas producers with natural draft, at 70 per cent.

The heat requirement, like the melting capacity, must be expressed on the basis of a working day. The heat required for the working compartment of the tank must enter into the calculation, but not, however, that of the flow spouts, fore-hearths, and drawing chambers.

4. *Specific Heat Requirement.* The specific heat requirement states how much heat is needed for melting one kg. of glass. It is given in kg. coal/kg. glass or kg. cal./kg. glass. On the basis of the same considerations applied to the absolute heat requirement, it is preferable here to use the datum kg. cal/kg. glass.

The specific heat requirement, in contrast with the specific melting capacity, is not based on the tank area but on the weight of glass manufactured; and in this way it furnishes a measure of the efficiency of a furnace from the thermo-technical point of view.

The specific heat requirement depends upon two major conditions, the load or pull on the furnace and the utilization of heat in the furnace. A good specific heat requirement results only if these two major conditions are entirely favorable.

5. *Special Data.* Other data which customarily enters into the reckoning are not treated here, because the four types of data already named exert the greatest influence on capacity and heat requirements.

Nomograph

The nomograph (Fig. 2) serves to give the most convenient method of calculating relationships between the items of numerical data. The symbols employed signify:

S = absolute melting capacity (t/24 hr.)
s = specific melting capacity (t/m^2/24 hr.)
F = Tank area (m^2)
Q = absolute heat requirement (10^6 kg. cal./24 hrs.)
q = specific heat requirement (kg. cal./kg. glass)

The left-hand side of the nomograph serves for the measurement of specific melting capacity according to the formula: $s = \frac{S}{F}$ and the right side for the measurement of specific heat requirement according to the formula: $q = \frac{Q}{S}$.

To show the process of reading off a value, a broken line has been drawn across the diagram for an example. From the melting-capacity value, which is found on the middle vertical line, one goes to the left to the radiating line corresponding to tank area, from this point vertically to the directrix or guide line, and again horizontally as far as the left-hand vertical line, upon which the specific melting capacity, either in tons/m^2/24 hr., or in the parallel units in kg./m^2/hr., can be read. Going from the middle vertical line toward the right, one finds in corresponding fashion, by way of radiating division line and directrix (here a curve) from melting capacity and absolute heat requirement, the specific heat requirement. For the reverse process of calculation, the broken line takes the opposite direction. The broken line shown on the diagram corresponds to the following selection of data:

S = 45 t/24 hrs.
F = 70 m^2
Q = 140 x 10^6 kg. cal./24 hrs.

From these values the nomograph gives:

s = 0.645 t/m^2/24 hr. = 26.8 kg./m^2/hr. [= 5.49 lb./ft.^{2}/hr.]
q = 3100 kg. cal./kg. glass. [=5580 B.t.u./lb.]

ADD NEW BATCH COMPOSITIONS

Editor, THE GLASS INDUSTRY:

In U. S. Patent No. 2,215,209, the inventor claims a frost-resistant glass can be made by mixing the batch with alcohol and water, heating the mixture to dryness, melting the batch thus prepared and forming glass articles from the melt. Perhaps he would have used more powerful anti-freeze liquids such as glycerine if he had found it necessary or the cost had not been prohibitive. He does propose to use common salt, which is much cheaper than alcohol and also a very good melter of ice—if it should survive the melting process.

The gullibility of the patent examiners in this instance is nothing short of amazing. If they had the rudiments of technical knowledge, they would have been just as willing to grant a patent on a method for putting the alcohol inside the glass workers engaged in producing the ware.

S. R. Scholes

CERAMIC CAMERA CLUB SALON

The 3rd Annual Salon of The Ceramic Camera Club will be held in the Lord Baltimore Hotel in conjunction with the Forty-Second Meeting of The American Ceramic Society. A competent jury of selection has been secured consisting of J. S. Rowan, Chairman, Charles E. Emery and W. D. Barkley. These men are well known in the international field of photography, and all reside in Baltimore at the present time. Mr. Rowan is secretary of the pictorial division of The Photographic Society of America.

The Frazier Award will again be given to the member of the American Ceramic Society submitting the most outstanding photograph at the Ceramic Club's Annual Salon. The Award Committee this year consists of Prof. Joseph P. Thorley, Chairman, Charles D. Spencer and Francis C. Flint.

Entry blanks will be mailed to all club members on February 15. The closing date for receiving prints will be Saturday noon, March 29. Members of the American Ceramic Society wishing to exhibit and not belonging to the Ceramic Camera Club, are requested to secure entry blanks for the salon by writing to the Club Secretary, Mr. J. Earl Frazier, Frazier-Simplex, Inc., 436 East Beau Street, Washington, Pennsylvania.

The Officers and Board of Control of The Ceramic Club are E. L. Hettinger, President, John R. Hostetter, Irwin W. Schoeninger, Junius F. Krehbiel, and J. Earl Frazier, Secretary-Treasurer.

BROCKWAY TO MAKE "SANI-GLAS"

The Brockway Glass Co., Brockway, Pa., has announced a new line of "Sani-Glas" perscription ware. Sani-Glas containers derive their name from the fact that they are sterilized under Westinghouse Sterile-Lamps. These lamps are placed in the cooling end of the lehr and again at the inspection stations where the bottle caps are applied. In this way, spores and bacteria that might be carried into the containers after they are cooled and before being sealed, are said to be destroyed.

• The Government's anti-trust suit against the glass container industry has been postponed until February 13.

FRANK E. BARDROF

Frank E. Bardrof, associate editor of THE GLASS INDUSTRY, died at his home in Shaker Heights, Ohio, on Wednesday, January 15. For more than a year Mr. Bardrof was in poor health, his illness being diagnosed finally as Hodgkin's disease, and repeated blood transfusions failed to check progressive anemia, which is a characteristic of that malady.

Mr. Bardrof was born in Oriskany Falls, N. Y., in 1889. He was educated in the schools of that city and also at Cazenovia Seminary. He was graduated with high honors from the Rensselaer Polytechnic Institute in 1913, to which he was recalled as an instructor, and there he taught mechanical design.

In 1917 he became associated with the Mechanical Development Department of the Corning Glass Works, where for more than six years he was engaged in the design and development of glass making machinery. It was during this period that Corning was perfecting its "399" or "ribbon" machine, and Mr. Bardrof did a great deal of the work on this. His associate at Corning, Mr. David Gray, has said of him that he was one of the best theoretical machine designers he had ever known.

At about this time Mr. Bardrof had occasion to detect an error in a technical article appearing in The American Machinist, published by McGraw-Hill Co., and as a result of the ensuing correspondence he joined the staff of that paper as associate editor. In that capacity, his ability attracted the attention of one of the publication's advertisers, the Cleveland Worm and Gear Company. He shortly became sales manager of that company, a position he held until 1929. In 1937 joined THE GLASS INDUSTRY as its associate editor.

Mr. Bardrof was married in 1917 to Mildred Whitehurst, by whom he had two sons, James W. and Frank E. Bardrof, Jr. Mrs. Bardrof died in 1928. In 1931 he married Lillian Miller, then principal of the Boulevard High School in Cleveland.

Mr. Bardrof was a man of many qualities. His hobby was photography. Interested in music, and with a good voice, he sang in several choirs. A born leader, he was the prime mover in innumerable projects of his community. He had an insatiable interest in people, and this, with his irrepressible sense of humor and dry wit attracted all men to him.

CLYDE G. LUCAS

Clyde G. Lucas, assistant sales manager of the New York office of the Hazel-Atlas Glass Company, and United States manager of export sales for his company, died on January 13 as the result of illness. Mr. Lucas was 51. The association of Mr. Lucas with Hazel-Atlas extended over a period of 26 years, part of the time in the general offices and the major portion of it at the New York branch. He was recently an assistant to Mr. Brady, New York associate sales manager.

JAMES O. CORNER

Mr. James O. Corner, president of Consolidated Lamp and Glass Company, Coraopolis, Pa., died suddenly Monday afternoon, January 20 at Vero Beach, Florida. Mr. Corner was born November 13, 1886 in Toronto, Canada, and spent much of his early life in the northern part of Canada. He was employed by the Canadian National Bank during this period. He later became associated with exporting firms in New York, and at one time was a vice president of the Republic Oil Company.

G. C. A. SHIFTS PERSONNEL

Mr. Scott Faron, advertising manager of the Glass Container Association, has resigned to assume a position with the Ward Wheelock Company of Philadelphia, Pa. Previously he had been advertising manager of Ross Federal Service and Ross Federal Research Corporation. Pending the approval of the Association's Board of Directors, Mr. V. L. Hall, now secretary and treasurer, has been appointed to take over the duties of Mr. E. G. Ackerman, who recently assumed the presidency of the Thatcher Manufacturing Company. Mr. H. W. Kuni has been appointed to assume the work connected with the office of secretary and treasurer. Mr. F. P. Gass will be in charge of public relations and trade promotion. Following the next meeting of the Board of Directors, a further announcement will be made.

F. H. MAY JOINS FOSTER-FORBES

The Foster-Forbes Glass Company, Marion, Ind., announces that effective March 1, Mr. Francis H. May will be vice president in charge of sales. Mr. Mays was formerly with the Armstrong Cork Co. in their container division, and previous to that, was vice president and treasurer of the Hart Glass Manufacturing Company.

• The Chas. Taylor Sons Company, Cincinnati, Ohio, announces the appointment of Mr. A. O. Schleiffarth as its St. Louis sales representative. Mr. Schleiffarth will also cover the territory of Western Illinois, Eastern Iowa and Missouri.

CURRENT STATISTICAL POSITION OF GLASS

December witnessed a continuation of the previous month's record activity in the glass industry, bringing 1940's total output to an all-time high. Employment and payrolls were maintained at the November level; exports continued heavy as the import trade remained at a greatly reduced volume. According to THE GLASS INDUSTRY's Production Index, December's output equalled the November figure of $35,000,000, making the twelve months' total $368,000,000, a new record. This represented an increase of 15 per cent over 1939 and was 4 per cent greater than the previous record set in 1937.

Plate glass production during December totaled 17,491,218 square feet, according to the Plate Glass Manufacturers of America. This represented an increase of 9 per cent over November, but was 5 per cent less than the December 1939 figure.

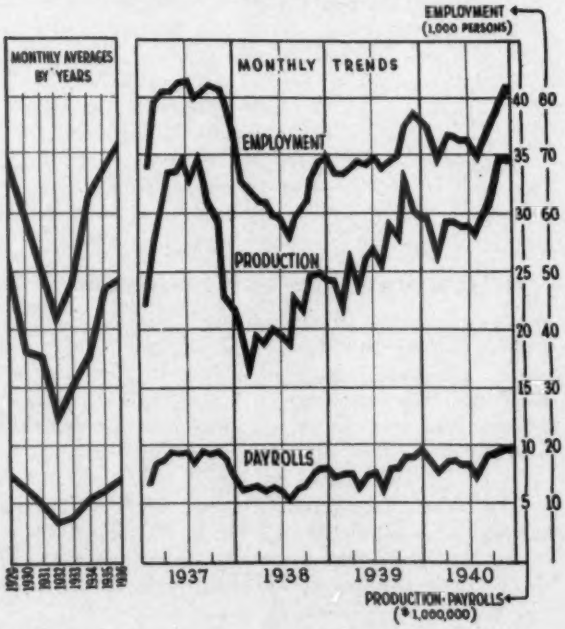
Complete figures for the full year of 1940 placed plate glass output at 164,371,570 square feet which was 16 per cent greater than in the previous year but was 15 per cent under the 1937 total and 17 per cent less than the record of 198,069,000 square feet set in 1936.

Window glass output during December amounted to 1,457,933 boxes, which exceeded all previous monthly totals. It was 15 per cent greater than November's figure and 23 per cent above the December 1939 level.

A new window glass production record was set in 1940 with a total of 13,678,927 boxes reported. This was 35 per cent greater than 1939's output and exceeded the 1937 record by 1 per cent.

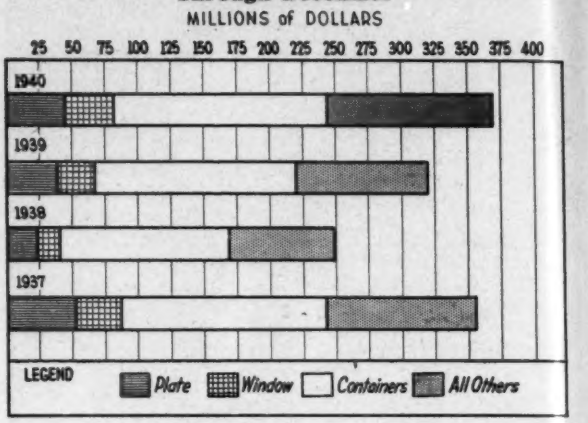
THE GLASS INDUSTRY'S INDEX

Monthly Trends Through December, 1940



THE GLASS INDUSTRY'S INDEX

Production for Twelve Months, January Through December



Glass container production during December totalled 4,202,978 gross according to the Glass Container Association of America. This was 3 per cent below the previous month's total, but was 4 per cent above December 1939. Beer bottles and pressure and non-pressure ware were the only items that increased over November, while medicinal and toilet ware and beer bottles were the only items that dropped below the December 1939 level. Production for the full year of 1940 totalled 54,264,509 gross—the largest in history. This volume exceeded 1939's figure by 6 per cent and was 1 per cent greater than the previous record set in 1937.

Shipments during December dropped 13 per cent below the November total to 3,531,647 gross. This was 15 per cent more than the December 1939 figure. Medicinal and toilet ware accounted for 29 per cent of the total, food containers 22 per cent, liquor ware 22 per cent, general purpose ware 9 per cent, milk bottles 7 per cent, soft drink bottles 6 per cent, and beer bottles 5 per cent. Food containers, liquor ware and medicinal and toilet ware were the only items that declined from the November level, but they accounted for so large a percentage of the total that they brought the general trend down. All items participated in the increase reported over December 1939. Shipments for the twelve months of 1940 totalled 52,287,932 gross—another new record. This was an increase of 6 per cent over the previous year.

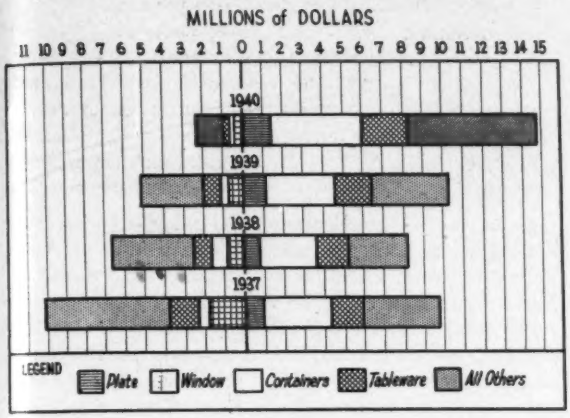
Stocks on hand at the close of 1940 amounted to 9,988,210 gross which represented an increase of 8 per cent over last year.

Miscellaneous glass products manufactured in December had a value of $14,000,000, equaling the previous month's estimates. During the full year of 1940 this output totalled $127,000,000 as compared to $103,000,000 in 1939, and $114,000,000 in 1937.

Production of machine made tumblers during December totalled 3,198,953 dozens which was 20.6 per cent more than 1939's comparable figure (2,652,194 dozens).

THE GLASS INDUSTRY'S INDEX

Foreign Trade for Twelve Months, January Through December



During the twelve months of 1940, production increased from 40,428,111 to 43,600,762 dozens, a gain of 7.8 per cent. Shipments were 9.5 per cent greater than in December of the previous year, totalling 2,875,890 dozens. Cumulative totals for 1940 brought shipments 8.7 per cent above the 1939 level to 42,165,273 dozens—an all time record. Stocks-on-hand as of December 31, 1940, totalled 8,454,815 dozens.

Shipments of machine made table and kitchen glassware during December totalled 2,455,674 dozens—slightly below 1939's level (2,662,977 dozens). Production for 1940 totalled 33,592,796 dozens.

According to a preliminary report from the Bureau of Census, illuminating glassware sales during December dropped 2 per cent below the November level but were 12 per cent above December 1939.

Employment and Payrolls: Approximately 81,500 persons were employed in the glass industry during December, maintaining the previous month's level. This compared with 76,00 in December 1939. An average employment of 75,300 persons is estimated for the full year of 1940, an increase of 8 per cent over last year.

Payrolls in the glass industry during December remained at the November high of $10,000,000; in December 1939 they totalled $8,900,000. During 1940 glass manufacturers paid out $104,000,000 in wages, the largest in history; this compares favorably with last year's total of $88,000,000.

Foreign Trade: Exports of glass and glass products during December decreased 14 per cent below the November figure to $1,532,000. However, this volume was 44 per cent greater than December 1939, bringing the total for 1940 to $14,750,000—the largest since 1920. All types of glass participated in the decreases from November and the increase from December a year ago. The largest rate of increase over December 1939 was recorded for window glass.

1940's export trade was 41 per cent larger than the 1939 figure. During this period outward shipments of window glass increased 928 per cent, illuminating ware 55 per cent, plate glass 38 per cent, containers 32 per cent and tableware 35 per cent. Canada and Latin America continued as the leading outlets for these products.

Imports of glass during December rose 4 per cent above the November level to $114,000; this was 63 per cent below December 1939's total. The increase over November was due to a rise in window glass and tableware—all lines followed the downward trend from a year ago. During the twelve months of 1940, imports were valued at $2,312,000 which was the smallest annual volume since 1919 and represented a drop of 55 per cent from the 1939 total. Plate glass was the only item for which an increase was reported during this period.

UNITED STATES FOREIGN TRADE IN GLASS
(Values in Thousands of Dollars)

EXPORTS

	1940			1939		Percentage Changes..		
	December	November	Twelve Months	December	Twelve Months	November-December	December-December	Twelve Months
Plate	129	182	1527	102	1106	— 29	+ 26	+ 38
Window	133	163	720	20	70	— 18	+ 565	+ 928
Containers	375	529	4558	350	3454	— 29	+ 7	+ 32
Tableware	240	265	2448	204	1963	— 9	+ 18	+ 25
Illuminating Ware	65	92	732	59	473	— 29	+ 10	+ 55
All Other	590	546	4765	327	3395	+ 8	+ 80	+ 40
Total	1532	1777	14750	1052	10461	— 14	+ 44	+ 41

IMPORTS

Plate	1	1	119	5	75	—	— 80	+ 59
Window	18	6	359	27	793	+ 100	— 35	— 55
Containers	4	5	142	14	324	— 20	— 71	— 56
Tableware	24	16	415	61	873	+ 50	— 60	— 52
Illuminating Ware	3	9	72	14	375	— 67	— 79	— 81
All Other	64	73	1205	186	2718	— 12	— 66	— 56
Total	114	110	2312	307	5158	+ 4	— 63	— 55

INVENTIONS AND INVENTORS

A Summary of United States Patents of Interest to the Glass Industry Issued During December

Compositions

So thoroughly has the field of glass compositions been worked over by the many technical workers in this field that it is unusual for more than one or two composition patents to be issued in a single month from the United States Patent Office. Occasionally, however, a more or less new field is opened up, as has resulted from the phenomenal public adoption of fluorescent lighting. Even greater activity in this field can be expected as it spreads beyond store and industrial uses to the almost limitless possibilities which will come with its application to private homes. The characteristics of the visible light from such elements are governed by the nature of the chemical substances applied as a coating to the glass tubes. One such coating mixture was covered in a December patent, 2,226,404 issued to Henry G. Jenkins of Pinner, England and Alfred H. McKeag of Middlesex, England, (General Electric Co.). One of the usual luminescent silicate mixtures is mixed with 1 to 30 per cent of carbonates from the group consisting of barium, strontium, calcium, zinc, cerium and thorium. Other luminescent compositions were covered by patent 2,226,407, also granted to Mr. McKeag.

Corning Glass Works, whose composition research apparently continues active, was granted patents for two different types of glasses. These were Henry H. Blau's patent 2,224,469 and William C. Taylor's patent 2,224,493. The Blau patent is concerned with the development of fluorine-containing opal glasses having high reflection coefficients. In melting glasses of this type Mr. Blau reports that the loss of fluorine is excessive, due, he has found to the use of lime and other elements of the same group, and to the use of batch constituents which contain water. Common examples of the latter are borax, boric acid and hydrated alumina. According to his invention, he prefers to use batch constituents which produce glasses containing in addition to fluorine, only silica (generally a 70 per cent minimum), alkalies and alumina, with the alkalies being 1.85 to 3.5 times the alumina.

In the Taylor patent, which concerns a high silica glass, emphasis is placed on long working range. An exceptionally low dielectric constant is reported. A typical composition is 80-85 per cent silica, 10-15 per cent sodium oxide, 2.5-7.5 percent alumina, and generally smaller percentages of lime and fluorine.

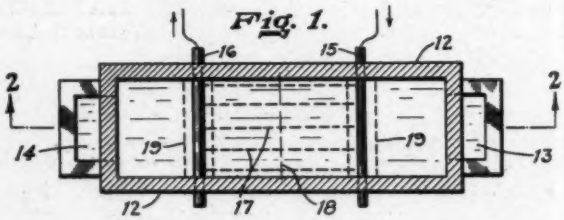
Patents were issued for two types of phosphate glasses. The aim of Edgar D. Tillyer and Townsend M. Gunn (American Optical Co.) in patent 2,226,418 was to produce an infra-red and ultra-violet absorbing glass which would be substantially colorless. Their batch compositions are stated to contain as much as 60 to 81 per cent phosphates, as HPO_3. Other constituents are 1 to 20 per cent alumina plus berillia, 1 to 15 per cent barium carbonate and 1 to 10 per cent ferrous phosphate. Hans Grimm of Heidelberg and the late Paul Huppert assigned to Walter H. Duisberg of New York, their patent 2,227,082 for phosphate glasses with very low softening temperatures (below 400°C), and low solubility in water. Their glass compositions may be expressed as follows:

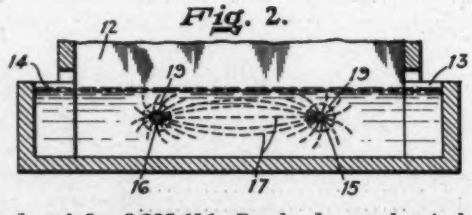
Phosphorus pentoxide	34-44 per cent
Alumina	20-30 per cent
Boric Oxide	12 per cent Maximum (with 6 per cent replaceable by zinc oxide).
Alkalies (Na_2O+K_2O)	25 per cent Minimum (and neither alone to exceed 21 per cent).

Color control in selenium ruby red glasses has been the subject of many research projects. The latest contribution is patent 2,224,791 assigned by Hans Löffler of Berlin-Dahlem to Deutsche Gold und Silber Scheideanstalt, vormals Roessler, Frankfort-on-the-Main, Germany. Löffler describes the familiar process in which cadmium issued with the selenium, in the presence of sulphur present as zinc sulphide. Such glasses are heated a second time to fully develop the ruby color. Löffler replaces the zinc sulphide by an agent from the group consisting of alkali metal sulfides, alkali metal thiocyanates and zinc thiocyanate, and states that the formation of color in the reheating step is accelerated.

Furnaces

Two patents relating to tank furnaces heated wholly or partially by an electric current flowing through the glass mass were granted to Edouard V. Borel, Sous-le-Poyet at Romont, Switzerland, and assigned to Societe Anonyme des Manufactures des Glaces & Produits Chimiques de Saint-Gobain, Chauny & Cirey, Paris, France. In patent 2,225,616 electrodes, preferably completely immersed in the path of the circulating glass current, are extended across the furnace, as indicated in Figs. 1 and 2. Many other arrangements are described. Referring to Fig. 1, the combined surface area of the two electrodes 15 and 16 is required to be less than the vertical cross sectional area of the glass between them. Other numbers and





Figs. 1 and 2. 2,225,616: Borel. In an electric heated glass tank furnace this electrode arrangement is the most elementary of a number suggested. Glass flowing from the charging end 13 toward 14, is required to flow through an area in which heat is concentrated by electrodes of which at least one is completely immersed.

arrangements of electrodes are detailed. The second Borel patent 2,225,617, also concerned with an electric heated tank furnace, provides two or more electrodes reaching across the tank and places between them conducting rods (such as are made of graphite) to concentrate the current in the desired channels.

Modified Owens Machines

The great expense involved in altering the design of essential parts of a standard glass machine is an ever present deterrent to major evolution in this class of equipment. However, the deficiencies of commercial forming machines are well known to plant operators, and this realization is responsible for a continuation of concentrated research on machine development. An important Owens-Illinois research program has just culminated in the issuance of a group of four patents which collectively represent new operating principals. These improvements are applied to automatic suction gathering forming machines of the Owens type. As individual publications these patents will be of great interest to all who work with automatic forming machines. The inadequacy of any brief review of these patents can best be indicated by stating that one of the four includes 133 drawings detailing the operation of 1036 separate parts. Nevertheless the principles of operation can be mentioned briefly. The four patents involved are 2,225,898; 2,225,899; 2,225,631 and 2,227,374. The following inventors had a part in one or all of the four patents: Joseph P. Benoit, Clarence C. Kinker, Russell G. Allen, Harold A. Rohrich of Alton, Ill., Carl W. Schreiber of Toledo, John B. Hawley Jr., Irving Nelson, and Daniel F. Hallberg of Minneapolis, and Earl Cannon of Rockville Center, N. Y.

In designing the new machine a primary object was to obtain compactness, and specifically to build the machine to a smaller radius than machines of this type in general use. The machine is adapted also to make simultaneously different shapes or sizes of ware on different heads. This requirement posed problems which were met in patents 2,225,898 and 2,225,631 by providing separate power sources for carrying out the major operations. The problems of synchronization which are fully present in any forming machine, were naturally multiplied by these changes. Flexibility was provided to the extent that the timing of the various movements of any individual head may be changed without necessarily affecting the others.

In certain of these patents, means are described for decelerating the movement of the mold carriage to permit a slow movement during each charge gathering operation, and a resumption of speed between gathering operations.

In the standard Owens type of machine each finishing mold is carried at the outer end of a radially disposed arm by which the mold is swung upward to receive a parison from the gathering mold and then swung downward so that it clears and passes beneath the gathering pot during its travel with the mold carriage. In the improved machine the finishing mold is given a combined vertical and swinging movement which permits abbreviation of the mold-carrying arm and allows an important reduction in the radius of the mold carriage.

The scope of patent 2,225,898 is in part indicated by its issuance with one hundred and one claims. This is unusual in view of the attitude of the present Patent Examining Staff who frequently rejects patent claims solely

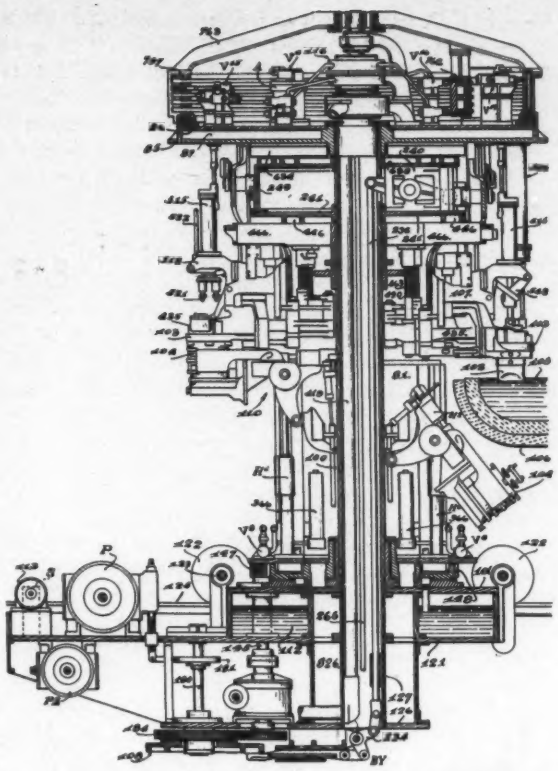


Fig. 3. 2,225,898: Modified Owens Bottle Machine. Designed by Benoit and Associates. This is a partly sectioned elevation view intended to give a general idea of the proportions of the machine. Major accomplishments are a decrease in the over-all radius of the machine, and the provision of individual head controls which permit different sizes of ware to be made successfully on various heads simultaneously.

on the grounds of multiplicity. In this particular patent the specifications call for carrying out all of the major operations by hydraulic power. However, in patent 2,225,899 some important functions are described as being performed by air motors. In patent 2,225,631 the retarded movement of the molds while receiving a charge is brought about by automatic means which reduce the fluid output of the hydraulic pump which controls this motion. Patent 2,227,374 is merely concerned with a safety device for preventing damage to a mold or tank when the two halves of the mold fail to close. An automatic means is provided which prevents the mold from moving to the gathering position.

Other Feeding, Forming and Shaping Patents

One method of forming vials or ampoules from glass tubing consists in heating a tubular blank between its ends, then pulling the cold ends away from each other to constrict the softened center, and finally applying a sharp flame to sever the constricted portion and simultaneously to form a bottom on both blanks. In some operations the heated bottoms are pressed against a plate to form a flat bottom. This is difficult to perform properly if the bottom is required to be oval instead of circular. Improvements in this and other steps of vial forming are proposed in patents issued in December to the Kimble Glass Co., Vineland N. J. These are 2,227,224 issued to

Herman K. Kimble and Joseph Chertok, and 2,224,486 to Harry Richter. A third patent 2,226,303, issued to Jacob Dichter of Berlin, Schoneberg, Germany, while not assigned to the Kimble Glass Co., may bear some relationship to the Kimble patents since the same attorney handled all three patents. Patent 2,227,224 provides a vial bottoming machine in which the ordinary functions described above are supplemented by automatically supplying air pressure through the vial to force the heated end against a bottom-shaping cavity. The Dichter patent is also concerned with the bottoming step. Harry Richter's patent is intended to overcome a disadvantage of ampoules made on machines of the type described in the Dichter patent 1,962,985 issued in 1934. In sealing both ends of these ampoules the heating operation rarifies the air, so that when the neck is subsequently scored and broken there is danger of tiny glass fragments being drawn into the ampoule. Richter's improvement provides a step wherein the neck is punctured by a sharp flame above the fracture line to relieve the vacuum.

Fig. 4 shows a mold assembly designed by Dore O. Headley, Washington Pa. (2,226,905 assigned to Hazel-Atlas) for manufacturing a reservoir-containing ink well.

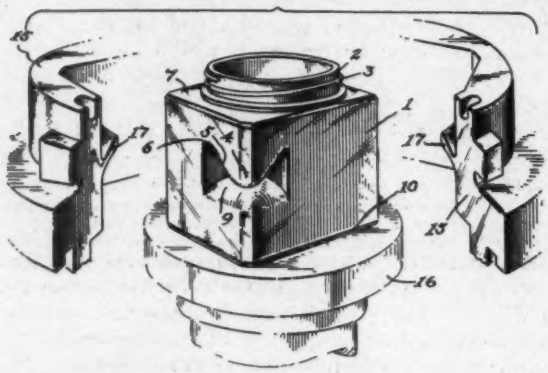


Fig. 4. 2,226,905: Headley. Mold design for an inkwell with reservoir or pocket.

A paste mold forming machine designed to produce better ware more economically than by the usual hand processes was patented by Robert J. Beatty, Columbus, Ohio. This is 2,225,948, assigned to the Federal Glass Co.

Means of timing separately and synchronizing the various steps of feeding, gob severing, and shaping while a forming machine is running, were covered in patent 2,224,767 assigned by David I. DuBois, Millville, N. J. to the Armstrong Cork Co. Very real progress is believed to have been made as is evidenced by the statement that "The forming of defective or non-uniform articles is a thing of the past."

Fig. 5 shows certain elements in an improved suction cup feeding machine disclosed in patent 2,224,759 granted to Robert W. Canfield of Wethersfield, Conn. (Hartford-Empire Co.).

George E. Rowe, also of Wethersfield, has assigned to Hartford-Empire Co. his patent 2,226,504 for a method of carrying out a press and blow forming process. Fig. 6 illustrates two steps wherein a charge is gathered by suction and then brought to a position over a blank or parison press mold. The pressing smooths out the glass chilled by the shear blades, and gives an even distribu-

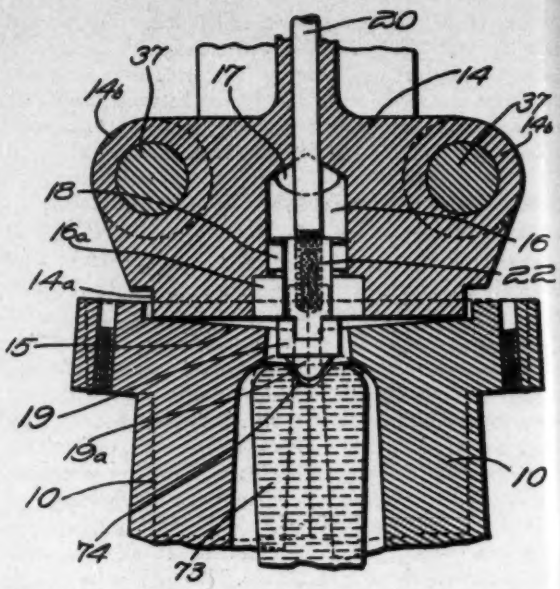


Fig. 5. 2,224,759: Canfield. The opening of the two sections of the suction head acts so that they impart an acceleration to the charge as it leaves the mold cavity.

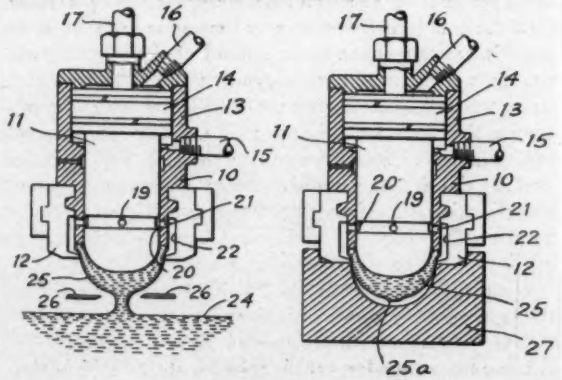
tion of glass around the plunger. In subsequent steps, which are not illustrated, the plunger is withdrawn to produce a hollow within the blank, and the blank is carried to a position over a blow mold wherein it is blown to final form.

In flowing glass from a forehearth for the production of a wide variety of glass Edward Danner of Newark, Ohio, places within the flowing glass a number of wires, some of which may be made to rotate, and may be heated. This is described in patent 2,225,369.

Decoration

The existence of important patents for the silk screen process of applying vitreous colors to glass is one compelling reason for continued research on alternative methods. An improvement in this field is claimed in patent 2,225,659 to Victor H. Remington and Ray Andrews, of Washington, Pa. (B. F. Drakenfeld & Co., Inc.). Their object was to provide a coloring material which when applied to a printing oil impression, made by a rubber

Fig. 6. 2,226,504: Rowe. Two steps of a press and blow process wherein a pressing operation smoothes or irons out surfaces chilled by the shears, and assures a uniform distribution of glass in thin walled articles.



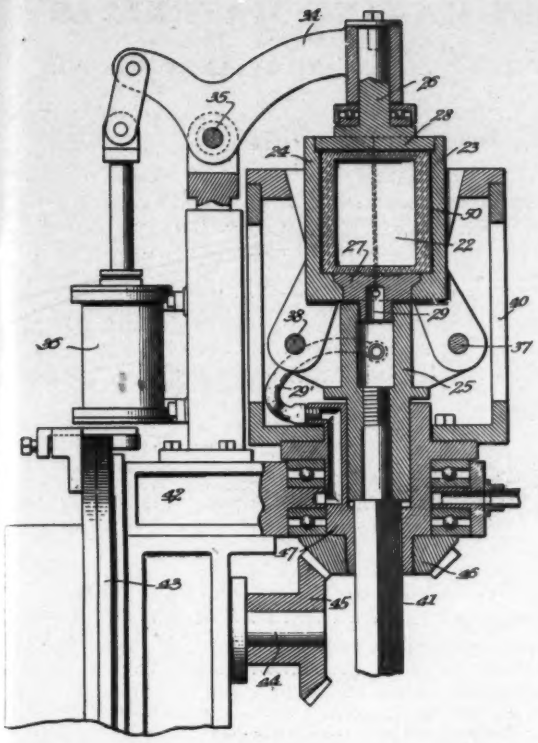


Fig. 7. 2,224,488: Rendall. In a centrifugal hollow block forming machine the mold spins on shafts 25, 26 to force the gob to cover the mold walls. Vacuum is applied so the block will not collapse upon leaving the mold.

stamp, would be thoroughly "wetted" by the oil and would build up a heavy coating which after firing would equal the brilliance, opacity and uniformity, obtained by the silk screening process. Such a degree of success is said to have been obtained by the novel method of adding the dry color to acetone to form a paste, then adding a small amount of pine oil, and finally volatilizing the acetone. The acetone serves as a solvent to carry the pine oil to all parts of the material and leaves it so dispersed when it is volatilized. This color, due to its pine oil content, is said to have a worked affinity for the printing oil impression.

Gerald White of Toledo (Libbey-Owens-Ford Glass Co.) was granted patent 2,225,729 for a means of applying several different ceramic colors to be fired to a glass surface in a single heating. First one design is applied, through a stencil. Then with the stencil still in place the dried color is covered with a protective coating such as the whiting made by mixing ground chalk with alcohol and water. Then the stencil is removed and another color can be applied without precaution to keep it from overlapping the first. The final step is the baking or firing operation. It is reported that the whiting can then be brushed off and that it neither adheres to nor prevents the enamel under coat from maturing.

Plate and Sheet Glass

Patent 2,225,870 granted to Adolf Kämpfer of Charlottenburg, Berlin, Germany discloses a press for the manufacture of laminated safety glass.

In making laminated safety glass by the process utilizing the strengthening plastic as a liquid, Charles S. Shoemaker of Jeanette, Pa. (American Window Glass Co.) has developed procedures which minimize loss of ware due to bubbles in the plastic. In patent 2,224,236 he explains that both sheets are first brushed, and then vacuum cleaned before immediately applying the plastic.

Glass Blocks

An apparatus for casting a one piece hollow glass block by centrifugal means is described in patent 2,224,488, assigned by Wm. S. Rendall of Baltimore to Crown Cork & Seal Co. As shown in Fig. 7, a partable mold is mounted for spinning about a vertical axis on upper and lower spindles 25, 26. In operation, the top plate 28 is raised to allow the gob or gather to enter the mold; then the mold is closed and rotated while suction is applied. As the mold spins, centrifugal force causes the glass to flow upwardly and outwardly to completely close the block.

In glass blocks made by sealing two halves with metallic solder, Samuel F. Cox of Pittsburgh (2,226,220 to Pittsburgh Plate Glass Co.) covers the solder with asphalt or similar bituminous material to secure better mortar adherance.

Glass Wool and Fibers

As is frequently the case, all of the patents on glass fiber manufacture were those assigned to Owens-Corning Fiberglas Corp. These included four patents for drawing methods each granted to different individuals.

Clyde A. Baker, Stuart M. Dockerty and Richard L. Hamilton of Corning, contributed a blower structure (2,224,466).

Edwin J. Fisher of Kirkersville, Ohio, in patent 2,224,-149 disclosed an improved technique for grouping fibers into a strand for textile use. The group of fibers supplied from a single feeder is drawn over a light-weight concave guide covered with felt or other soft material, which is kept moist with oil or other substance, with which it is desired to coat the fibers. (*Continued on page* 79)

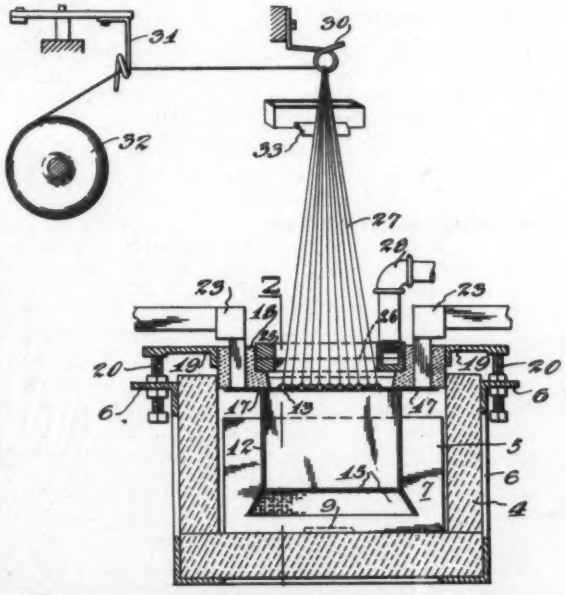


Fig. 8. 2,225,667: Staelin. Glass fibers are drawn vertically from an electric melting furnace and are frozen into fiber form by a cooling blower with jets at 26.

CURRENT PRICES OF GLASS-MAKING MATERIALS

FURNISHED BY PRODUCERS, MANUFACTURERS AND DEALERS

Base Materials

		Carlots	Less Carlots
Barium carbonate ($BaCO_3$), Crude, (Witherite)			
90%, 99% through 200 mesh	ton	43.00	46.00-49.00
Reduction on precipitated material, $5.00 a ton		45.00	50.00
Barium sulphate, in bags	ton	19.00	24.00
Barium sulphate, glassmaker's, carlots, bulk f. o. b. shipping point	ton	15.00-16.00	18.00
Borax ($Na_2B_4O_7 10H_2O$)	lb.	....	....
Granulated, In bags,	lb.	.0215	.027-.0295
Powdered, In bags,	lb.	.024	.0295-.032
Boric acid (H_3BO_3) granulated, In bags,	lb.	.048	.054-.0565
Calcium phosphate ($Ca_3(PO_4)_2$)	lb.	.07	.07¼
Cryolite ($Na_3Al F_6$) Natural Greenland (Kryolith)	lb.	.0865-.0875	.0925
Synthetic (Artificial)	lb.	No supplies available.	
Feldspar—(published list prices)			
20 mesh	ton	11.00-13.25	
40 mesh	ton	11.50-13.75	
Granular	ton	11.75-14.00	
Semi-granular	ton	11.00-13.25	
L. C. L., (Min. 2 tons) $3.00 per ton additional plus charge for bags			
Fluorspar (CaF_2) domestic, ground, 96-98% (max SiO_2, 2½%)			
Bulk, carloads, f. o. b. mines	ton	29.00	....
In bags	ton	30.60	40.00-42.50
Kryolith (see Cryolite)			
Lead Oxide (Pb_3O_4) (red lead) (N. Y.)	lb.	.08	....
In 5 Ton lots	lb.	....	.085
Less than 5 Tons	lb.	....	.09
Lime—			
Hydrated ($Ca(OH)_2$-MgO) (in paper sacks)	ton	8.50	8.50
Burnt (CaO-MgO) ground, in bulk	ton	7.00	....
Burnt, ground, in paper sacks	ton	9.00	9.00
Burnt, ground, in 180 lb. drums, Per drum		1.60	1.70
Kiln Dried ($CaCO_3$-$MgCO_3$) 10x30 mesh	ton	1.75	....
Kiln Dried ($CaCO_3$-$MgCO_3$) 16x120 mesh	ton	1.75	....
Nepheline Syenite, f. o. b. shipping point	ton	12.00	15.00
Potassium carbonate—			
Calcined (K_2CO_3) 96-98%	lb.	.065	.0675
Hydrated 80-85%	lb.	.055	.0675
Salt cake, glassmakers (Na_2SO_4) in bags	ton	18.00-20.00	25.00
in bulk		16.50	
Soda ash (Na_2CO_3) dense, 58%—			
Bulk, Flat	Per 100 lb	.95	....
In barrels	Per 100 lb.	1.35	....
In bags	Per 100 lb.	1.10	....
Sodium nitrate ($NaNO_3$)—			
Refined (gran.) in bbls	Per 100 lb.	....	2.50-2.90
95% and 97%			
Bulk	Per 100 lb.	1.35	....
200 lb. bags		1.44	1.465
100 lb. bags		1.475	1.50

Special Materials

		Carlots	Less Carlots
Aluminum hydrate ($Al(OH)_3$)	lb.	.026-.029	.04
Aluminum oxide (Al_2O_3)	lb.	.07	.09
Antimony oxide (Sb_2O_3)	lb.	.13	.13½
Arsenic trioxide (As_2O_3) (dense white) 99%	lb.	.03½	.04
Barium nitrate ($Ba(NO_3)_2$)	lb.	....	Open price.
Pyrophyllite, (20% Al_2O_3)	ton	9.00	12.00
Sodium fluosilicate (Na_2SiF_6)	lb.	....	
Tin Oxide (SnO_2) in bbls	lb.	....	.54
Titanium Oxide (ceramic grade)			
In bags	lb.	.13	.13¼-.13¾
In barrels	lb.	.13¼	.13½-.14
Zinc Oxide (ZnO)			
American process, Bags	lb.	.06½	.06¾
White Seal, 150 lb. bbls	lb.	.09	.09¼
Green Seal bags	lb.	.08¼	.08½
Domestic White Seal bags	lb.	.08¾	.09
Red Seal, bags	lb.	.07¾	.08
Zircon			
Refined Granular (Milled .01-.02c higher)		.03½	07-.08

Coloring Materials

		Carlots	Less Carlot
Barium selenite ($BaSeO_3$)	lb.	....	1.40-1.60
(Commercial, 25% Selenium)	lb.	....	.85
Cadmium sulphide (CdS)	lb.	....	1.00-1.05
Cerium hydrate—			
100 lb. drums and 600 lb. barrels	lb.	....	.60
Chrome Oxide Green, 400 lb. bbls	lb.	....	.22-.25
Chromite (99% through 200 mesh)	ton	45.00	48.50
Chromite ore (air floated)	ton	55.00	58.00-73.00
Cobalt oxide (Co_2O_3)			
In bbls, 350 lbs. or more,	lb.	....	1.84
Less than 350 lbs.,	lb.	....	1.94
Copper oxide—			
Red (Cu_2O)	lb.	....	.165
Black (CuO)	lb.	....	.18-.19
Black prepared	lb.	....	.22
Iron Oxide—			
Red (Fe_2O_3)	lb.	....	.05-.09½
Black (Fe_3O_4)	lb.	.04½	.09
Iron Chromate	lb.	....	.035-.05
Lead Chromate ($PbCrO_4$) in bbls	lb.	....	.135
Lithium Carbonate	lb.	....	1.00
Manganese, Black Oxide (Caucasian)			
In Paper bags	ton	70.00	78.00
In Burlap bags	ton	71.75	79.75
In Casks	ton	74.00	82.00
Neodymium oxalate, 50 lb. drums	lb.	....	4.00
Nickel oxide (Ni_2O_3), black	lb.	....	.35-.40
Nickel monoxide (NiO), green	lb.	....	.35-.37
Potassium bichromate ($K_2Cr_2O_7$)—			
Crystals and Granular	lb.	.08¾	.09-.09¼
Powdered	lb.	....	.09¼-.09¾
Potassium Chromate (K_2CrO_4) 100 lb. kegs	lb.	....	.27
Powder blue	lb.	....	.21-.25
Rare earth hydrate—			
100 lb. drums	lb.	....	.35
325 lb. barrels	lb.	....	.30
Selenium (Se) In 100 lb. lots	lb.	....	1.75
In lesser quantities	lb.	....	1.85
Sodium bichromate ($Na_2Cr_2O_7$)	lb.	.06¾	.07-.07¼
Sodium chromate (Na_2CrO_4) Anhydrous	lb.	.08¼	.08¾-.08½
Sodium selenite (Na_2SeO_3)	lb.	....	1.50-1.65
Sodium uranate (Na_2UO_4) Orange	lb.	....	1.65
Yellow	lb.	....	1.65
Sulphur (S)—			
Flowers, in bbls	Per 100 lb.	3.35	3.70-4.10
Flowers, in bags	Per 100 lb.	3.00	3.35-3.75
Flour, heavy, in 250 lb. bbls	Per 100 lb.	2.90	3.25-3.65
Uranium oxide (UO_2) (black, 96% U_3O_8) 100 lb. lots. Black	lb.	....	2.55
Yellow orange	lb.	....	1.65

Polishing Materials

		Carlots	Less Carlots
Emery, Turkish	lb.	.063	.07
Pumice Stone,			
American Ground Italian FFF, FF, F	lb.	....	open price
0, 0½, ½, 1.	lb.	....	open price
Putty Powder	lb.	Open price.	
Rotten Stone, (Domestic)	lb.	02¼	.03½
Rouge, Red	lb.	....	.16
Black	lb.	....	.18

"Ceramic" ICES

Give gay, colorful effects

Eye-Appeal . . . Color . . . Novel Effects—that's what makes cash registers ring with increased profits.

"Ceramic" Ices—vitrifiable crystals of selected particle size—come in crystal and all the popular colors to give a sparkling, crystalline-textured decoration to your ware.

Already making sensational sales on tumblers, fruit, cocktail, highball and water glass sets, "Ceramic" Ice may be used with equal success on many, many other items. It is easy to apply, has a wide firing range and presents an attractive, novel, colorful appearance.

Look over your list of products. See where you can use "Ceramic" Ice to advantage, then write or phone for sample and suggestions.

"Ceramic" Colors, Enamels, Oils

COLORS: Alkali Resisting, Acid Resisting, High Fire Convexing, Low Fire, Squeegee Colors—dry or paste; ENAMELS: White, Colored, Weather Resisting; ICES: Colored or Crystal; OILS: Squeegee Oils for Low Fire, High Fire or Overlapping Work; French Fat Oil; DECORATING SUPPLIES.

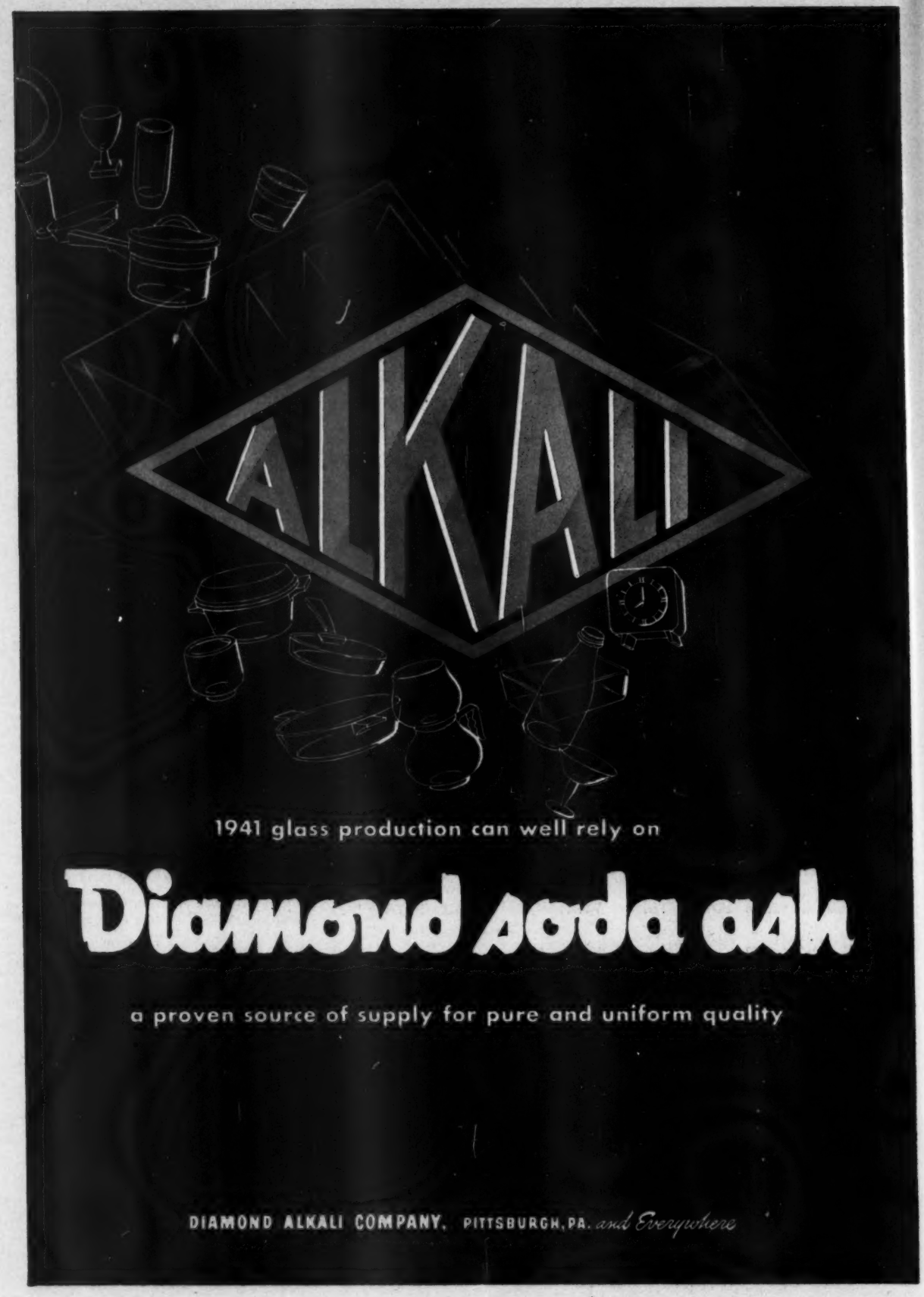
Chemicals

Alumina Hydrate	Iron Chromate
Antimony Oxide	Iron Oxides
Arsenic Oxide	Fluorspar
Barium Carbonate	Kryolith
Boric Acid	Manganese Dioxide
Borax	Sodium Uranate
Bone Ash	Sodium Selenite
Cadmium Sulphide	Selenium
Chromium Oxide	Sodium Silico Fluoride
Cobalt Oxide	
Copper Oxide	Zinc Oxide

"Ceramic" COLORS

CERAMIC COLOR & CHEMICAL MFG. CO.

NEW BRIGHTON, PA., U.S.A.


ALKALI
1941 glass production can well rely on
Diamond soda ash
a proven source of supply for pure and uniform quality
DIAMOND ALKALI COMPANY, PITTSBURGH, PA. and Everywhere

INVENTIONS AND INVENTORS

(*Continued from page* 75)

Patent 2,227,357 granted to Harold K. Martin of Beaver Dams, N. Y. replaces the noble metal feeder bushings of the standard Slayter-Thomas glass wool apparatus (patent 2,133,236 granted in 1938) and provides a comb-like arrangement of feeder plungers. The feeding unit consists of a refractory block extending across the furnace, and tapered toward the bottom, which tapered section is terminated by a metallic serrated tip. The teeth of the tip, resembling those of a comb, penetrate flow openings in the bottom of the furnace, and serve as plungers when the refractory block is moved vertically. An electrical potential may be built up on the plungers.

In the fourth Owens-Corning fiber forming patent (2,225,667) Carl G. Staelin of Toledo describes a means of drawing the fibers vertically from the glass surface rather than downward in the orthodox manner. The apparatus is illustrated in Fig. 8.

For bonding glass fibers to form felted products James F. Hyde of Corning, describes a process in patent 2,225,009, wherein an organic adhesive is applied and then the unit is carbonized in an atmosphere essentially free of oxygen. This patent and another concerning the use of glass textile articles in an oil insulated electrical conductor were assigned to Owens-Corning 2,224,484; Lester W. W. Morrow of Corning, N. Y.

Miscellaneous Products and Processes

James A. Morehead of Huntington, W. Va. received patent 2,223,382 for an automobile tail light lens, into which is molded a section of glass of different light transmitting properties from the main lens.

Improvements in edge lighted signs were patented by Louis J. Dixon, Chicago (2,223,409).

A high stemmed drinking glass illuminated by a small bulb and a battery within the stem were described in patent 2,224,319 granted to Robert M. Schroyer of Pittsburgh.

The Polaroid Corp. received patent 2,224,214 (Chas. H. Brown, Brooklyn) for a light polarizing body made of a transparant fusible material embedded in which are numerous minute parallel metallic wires, separated from each other by distances not exceeding ½ micron.

A lens surfacing machine was patented by Robert F. Duffers of Topeka, Kansas (2,225,826).

TO STUDY LIGHT RESISTANT GLASS CONTAINERS

Acting under the stimulus of the Food and Drug Administration, the U. S. Pharmacopea is about to initiate a study of the packaging of certain drugs that are affected by light. The study is in charge of a sub-committee of the U. S. P. Revision Committee, and known as the sub-committee on Packaging and Deterioration, headed by Dr. F. O. Taylor, Chief Chemist of Parke Davis & Co. Dr. Taylor will be assisted by a sub-committee of the Glass Division, appointed by Chairman W. R. Lester, and this will be known as the Glass Advisory Board to the U. S. P. Revision Committee. Francis C. Flint is chairman of this group, which includes U. V. Bowes, Owens-Illinois Glass Co., K. C. Lyon, Armstrong Cork Co., Donald E. Sharp, Hartford-Empire Co., in addition to Mr. Lester, ex-officio. The first meeting of this advisory group will be held in Washington, D. C., the first week in February.

The problem of developing protective glasses that will prevent the transmission of light rays is not a new one. Interest in the subject reached a climax some eight or nine years ago when Mayne R. Coe of the U. S. Department of Agriculture made numerous experiments from which he drew very broad conclusions. Mr. Coe also developed a certain glass, or rather color, which was called "Coe's Grass Green Glass." While both the experiments and the conclusions were attacked successfully[1] in *The Glass Packer*, yet the work was conceded even by its critics to have had value in focusing attention upon the photo-chemical action of certain light rays, particularly the ultra violet, in packaging. In view of the heated controversies of 1932 and 1933, it will be extremely interesting to follow the progress of this further study of the subject.

[1]See "The Truth About Light Rays and Their Effect Upon Glass Packaging," *The Glass Packer*, **12**, 2, 87. Also "Further Studies With Light Rays," *The Glass Packer*, **12**, 8, 497.

INCREASES OPTICAL GLASS CAPACITY

Work on the new addition to the experimental glass factory at the Bureau of Standards, Washington, D. C., is progressing rapidly. It is expected that construction work will be completed by mid-February and the plant fully equipped by April. The new addition is a single story and basement, paralleling and extending the existing building, and more than doubling its floor space.

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HARTFORD'S NEW BATCH MELTING SYSTEM
(*Continued from page* 56)

and low continuous operating capacities of the three sizes are approximately as below. Also, since the feeders may be operated from zero to 100 per cent of the total time it is apparent that any charging rate from zero to maximum capacity may be maintained. If, because of space limitations, it is necessary to install a smaller size feeder than normally recommended, the capacity of the feeder selected may be increased by changing the number of strokes per minute.

MAXIMUM AND MINIMUM FEEDING RATE FOR EACH FEEDER

Feeder Size	*Minimum Lbs./min. 1⅛" Stroke*	*Maximum Lbs./min. 2¼" Stroke*
18"	75	150
24"	100	200
30"	125	250

Summarizing the results obtained by its new melting system the Hartford-Empire Company states:

"This method has demonstrated many advantages. The doghouse is entirely enclosed with the resulting absence of stingout and dust in the factory. The fritting arch insures a glazing over of the batch in the doghouse thereby minimizing the carry over of batch dust into the ports and checkers. All metal parts are protected by the batch being fed. As used with the manually operated Hartford-Empire glass level gauge, the glass level can be maintained within plus or minus one-sixteenth of an inch. The operation and adjustment of the entire system is so simple that highly trained men are unnecessary.

The new Hartford batch system resulted from studies on furnaces carried on at Hartford under the supervision of Mr. Vergil Mulholland over a period of years. Patents covering the feeding machine have been issued to E. O. Hiller. The triangular doghouse construction is credited to A. K. Lyle, and other features of the development or commercial application to A. S. Crandon and H. W. McIntosh. Several additional patents are pending.

SUIT FILED AGAINST BULB MAKERS

A 137 page civil anti-trust action against the General Electric Company and the Westinghouse Electric and Manufacuturing Company, and ten other firms charged with monopolizing the electric light bulb industry was filed in Trenton, N. J. on January 27 in the U. S. District Court by W. F. Smith, United States Attorney.

The suits charged that the General Electric Company and the Corning Glass Works monopolized the manufacture and sale of glass bulbs and had control over frosted glass bulbs. Patent licensing agreements, it was alleged, gave General Electric and Westinghouse control of 90 per cent of such incandescent lamps made and sold in the United States, permitting them to fix resale prices and to suppress competition by independents.

The defendants are as follows: General Electric Co., Westinghouse Electric and Manufacturing Co., Corning Glass Works, American Blank Co., International General Electric Co., Empire Machine Co., N. V. Philips' Gloeilampenfabrieken, Consolidated Electric Lamp Co., Hygrade Sylvania Corp., Ken-Rad Tube and Lamp Corp., Chicago Miniature Lamp Works, and the Tung-Sol Lamp.

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MOLDS FOR GLASS PRODUCTS

(*Continued from page* 63)

Deterioration of the metal surface may have several causes such as (*a*) a change in the physical structure of the metal due to temperature and other conditions of operation, (*b*) oxidation or corrosion of the metal surface by the surrounding gases or by contact with "lubricants."

Foreign material that accumulated on the mold surface can be reaction or disintegration products of "lubricants" as well as reaction products of the metal itself such as oxides.

In any event, when a mold produces dirty ware it must be removed from the machine and repolished. Repolishing is a laborious hand operation and a major item of expense in the maintenance of molds.

There is little doubt that "dirty" molds are a resultant of many different and variable reactions and any attempt to solve the problem must mean close control of all these variables. This would involve: (1) determining just what the variables are, (2) finding how they can be controlled.

A problem of this sort cannot be solved entirely in the laboratory. The solution can only come through the closest cooperation between the practical operator and the technical investigator over a considerable period of time.

The function of a glass mold is two-fold; (1) to shape the exterior of the piece of ware and give it a good surface, (2) to take enough heat out of the glass to permit it to become sufficiently rigid to be safely handled from the mold.

These requirements seem quite simple and it would appear that with our present knowledge of the properties of the many materials available today we should be able to meet them in an entirely satisfactory manner. The conditions, however, involved in the use of these molds are rather complex, quite variable, and little understood. To properly analyze these conditions, devise means for their control, and then select mold materials that will operate satisfactorily under the standardized conditions, requires engineering skill of the highest order. It is not a problem that is likely to be solved by hit-and-miss experimentation.

BOOK ON TEMPERATURE

Glassmen will remember the "Symposium on Temperature, Its Measurement and Control in Science and Industry" held in November, 1939, at the Hotel Pennsylvania, New York. The meeting was sponsored by the American Institute of Physics in conjunction with the National Bureau of Standards, the National Research Council and twelve technical societies, among which was the American Ceramic Society and the American Society for Testing Materials. A summary of the papers most interesting to glassmen was presented in THE GLASS INDUSTRY, December, 1939. The American Institute of Physics announces that all papers presented at the Symposium will be published in full in a single volume entitled "Temperature—Its Measurement and Control in Science and Industry" which will sell for $11.00. Copies may be secured through THE GLASS INDUSTRY.

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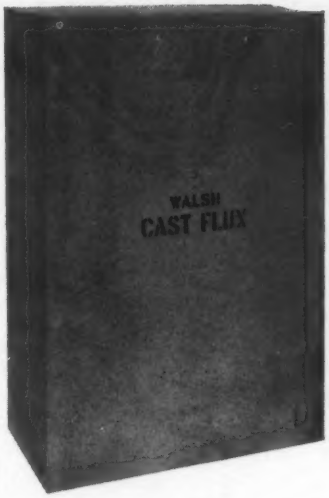

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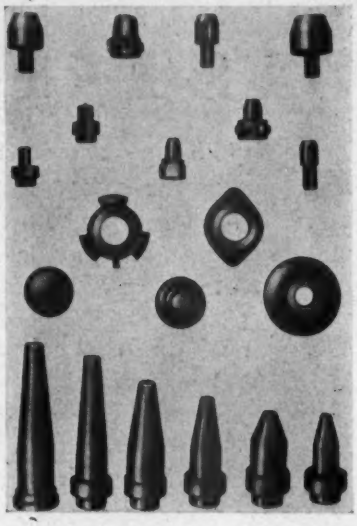

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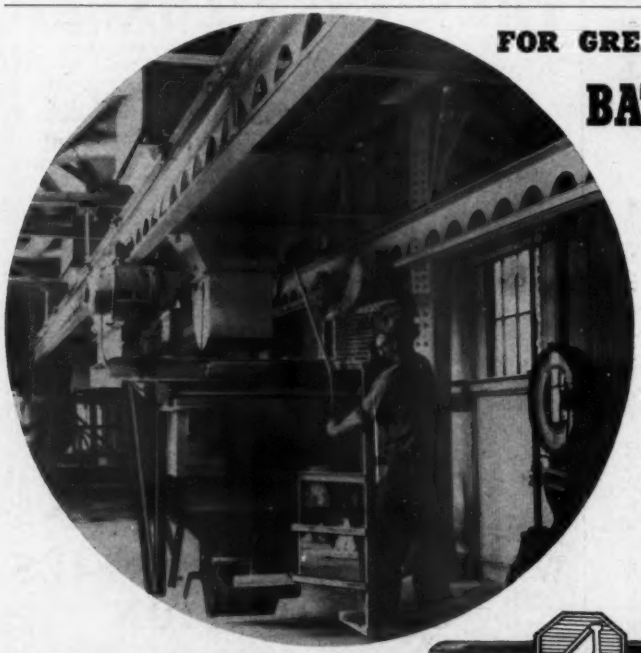

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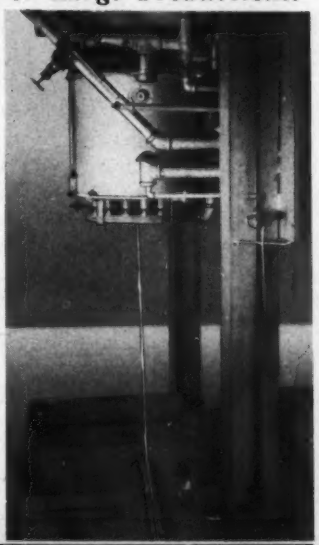

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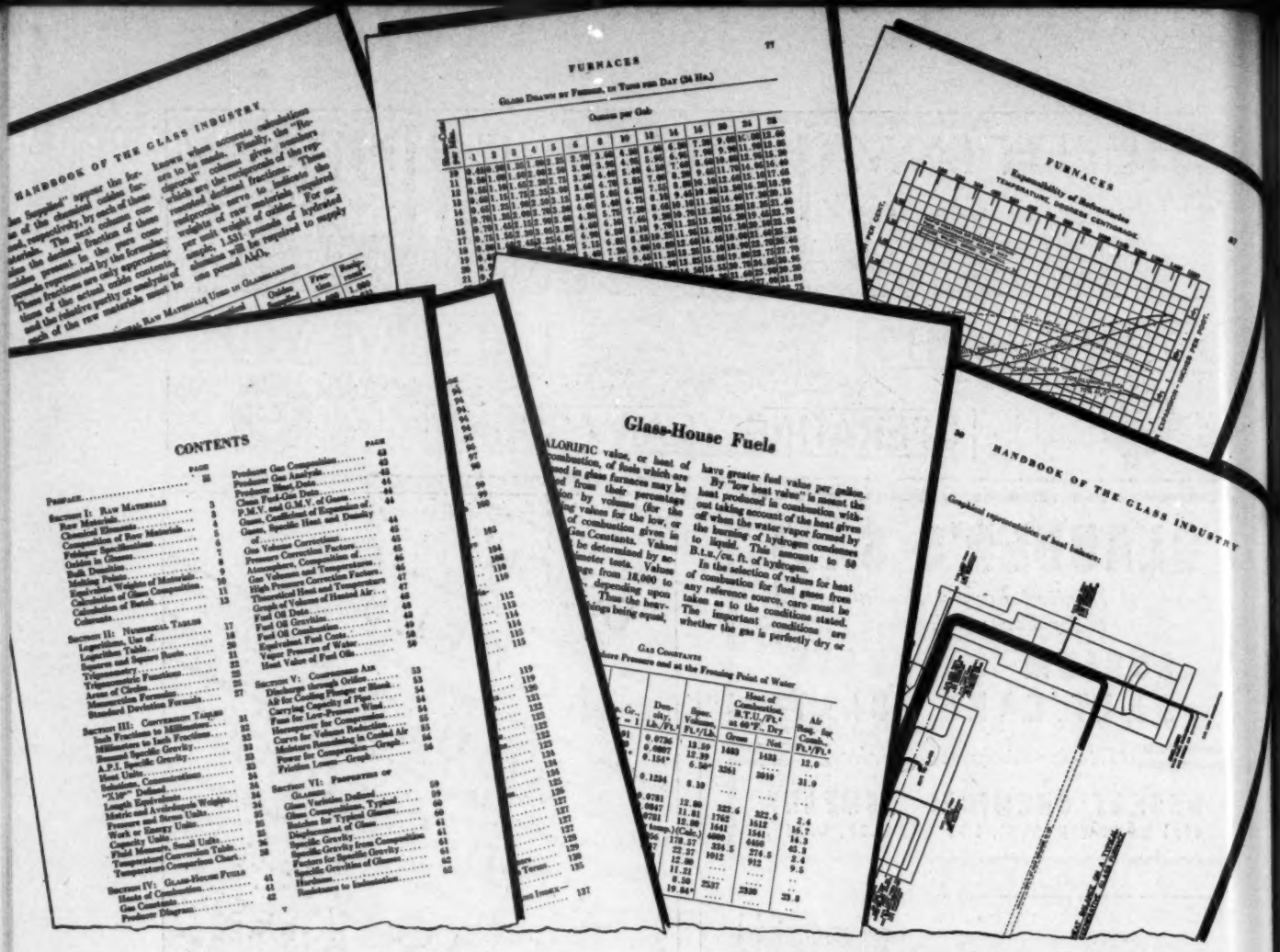

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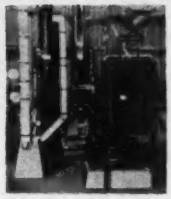
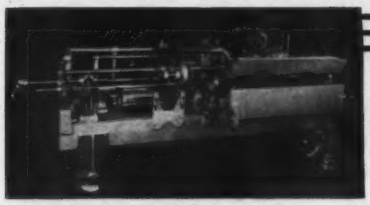
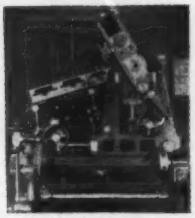


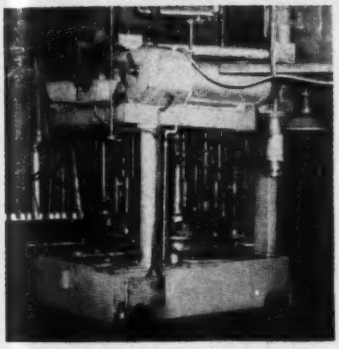
Fuel Oil Systems



Tube Drawing Machines



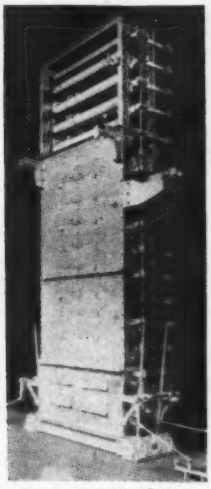
Rolled Sheet Glass Machines



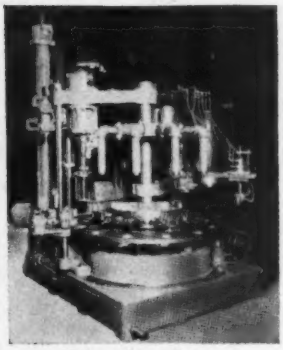
High Speed Presses

Grinding and Polishing Equipment

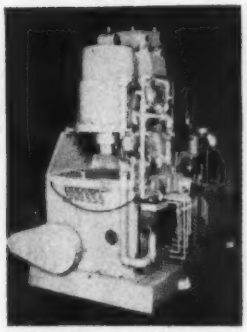
Marble Machines



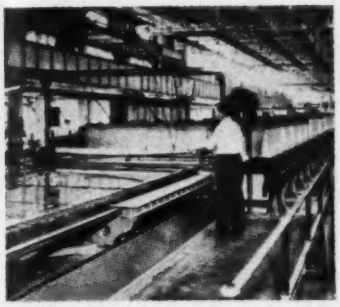
Fourcault Machines



Heavy Duty Presses

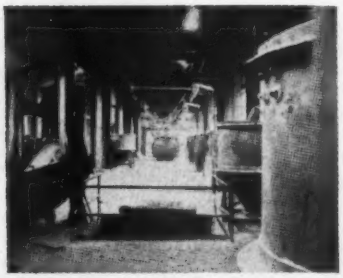


High Speed Tumbler Presses



Sheet Glass Lehrs

Container Lehrs



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